Recommendation #7: Regional office staff should have the ability to query and edit the central stocking database. All hatchery stocking reports should be reviewed by the local managing biologist for accuracy before they are forwarded to Olympia for entry into the central database.

Although the agency Beaver has avionics that can be programmed to place the airplane over the lake/s to be stocked, an experienced passenger should accompany the pilot on those trips where there is even a slight chance that the wrong lake could be stocked. These are usually instances where several small lakes lie in a tight cluster. An "expert passenger" policy would essentially eliminate the risk of stocking the wrong lake.

Recommendation #8: The district fish biologist, or other individual thoroughly familiar with the water/s to be stocked, should accompany the fixed wing or helicopter pilot on stocking runs where there is any potential for an inability to correctly identify the target water.

5.5 HATCHERY PRODUCTION PROGRAM

As mentioned in Section 2.0, trout culture and subsequent stocking into Washington high lakes preceded the establishment of the Washington Department of Game in 1933 by many years. A partial history of stocking by other agencies is given in Table 18 to illustrate this point. The following section will broadly review the WDFW cultural program over the past 20 to 30 years, and provide an emphasis on current practices.

Table 18. Early Stocking of Washington High Lakes by the United States Forest Service, National Park Service, and the U.S. Fish And Wildlife Service.

Years	Agency	Number of Lakes Stocked	Fish Species	Number of Fry Stocked
1914 -	USFS*	53+	EB, KO, RB, CT	720,175
1918 – 1973	NPS	50	EB, RB, CT	429,620
1956	USFWS	4	EB	45,430

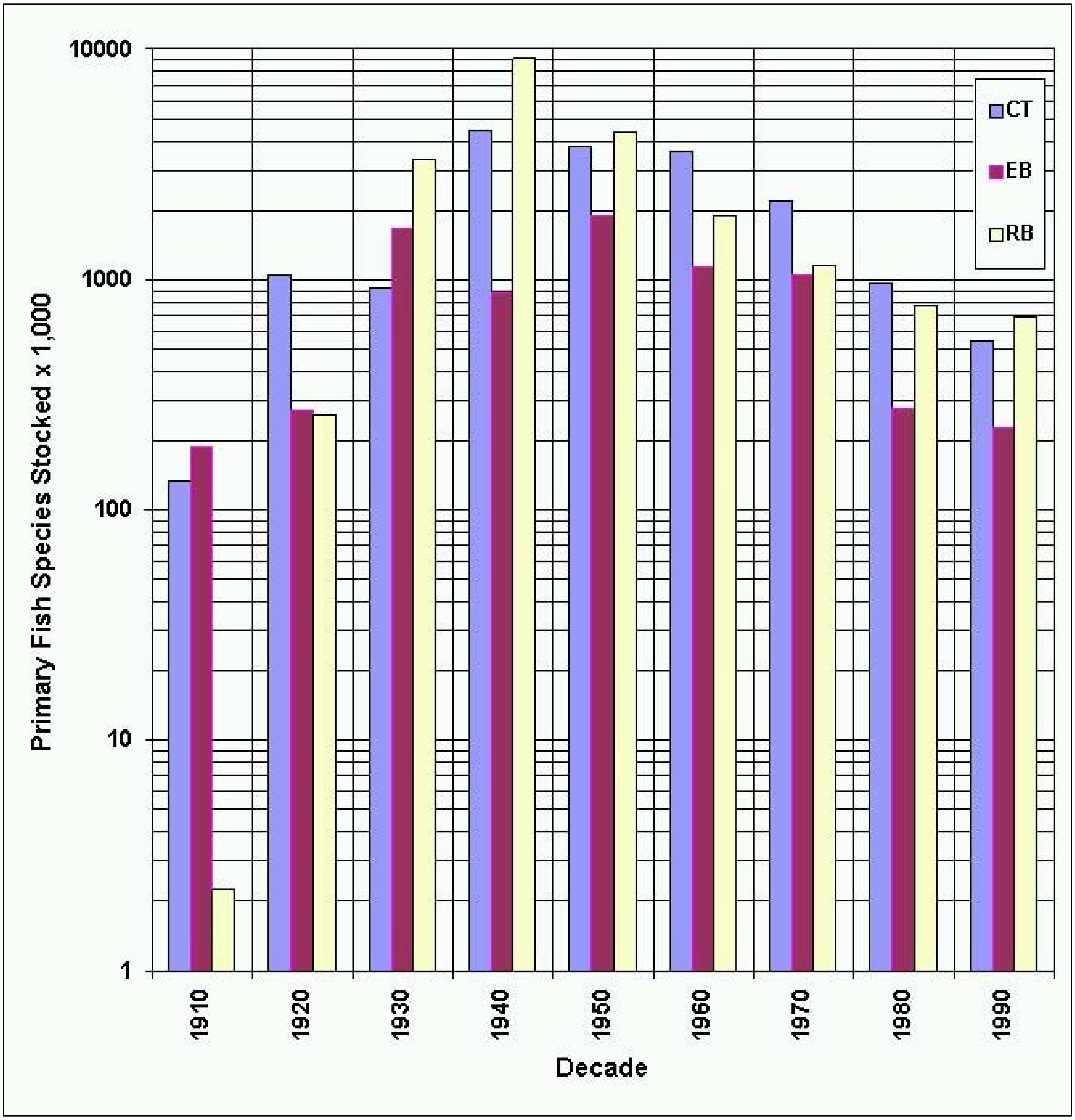
* The US Forest Service continues to stock high lakes in cooperation with WDFW.
Sources of data are archival stocking records from WDFW and NPS.

Fry stocked into Washington's high lakes are produced from either captive brood stocks, or semi-wild fish from broodstock lakes. Exceptions are exotic species such as lake trout or golden trout that are periodically imported from other western states, and test introductions of unusual species or hybrid strains (e.g., atlantic salmon, steelhead x golden hybrids, etc.).

5.5.1 Stocking Statistics

Early recognition of the need to maintain low-density fish populations in Washington high lakes is reflected in a plot of the total number of fry stocked annually (Figure 14). The sharpest declines are with species that are known to reproduce, creating conditions that are adverse for native invertebrate and amphibian biota.

Figure 14. Total Number of Eastern Brook, Rainbow, and Cutthroat Trout Fry Stocked into Washington High Lakes by decade, 1909 to 2000.



5.5.2 Species and Strains Historically Used

A lengthy list of species and strains has been introduced into Washington high lakes since the early 1900s (Table 19). The earliest introductions used the most commonly-available salmonid game species. Since many of the earliest introductions were made by federal agencies (Table 18), fish were commonly obtained from federal hatcheries. Eastern brook trout may have been the first species officially stocked, but cutthroat and kokanee were also available between 1911 and 1915 from early local hatcheries such as Lake Whatcom (near Acme), Tokul Creek (near Snoqualmie), and Twin Lakes (near Leavenworth)(Crawford 1979).

Table 19. Earliest Introduction of Fish Species and Strains Stocked into Washington High Lakes Per Available Documentation

Species	Strain	Year Introduced	Sponsoring Agency
Eastern Brook	Unknown	1914	USFS
Rainbow	Unknown	1917	USFS
Rainbow	Kamloops	1932	Unknown
Rainbow	Mount Whitney	1946	WDG
Kokanee	(Lake Whatcom presumed)	1917	USFS
Cutthroat	Unknown	1909	NPS
Cutthroat	Coastal	1965	WDG
Cutthroat	Westslope (Twin Lakes)	1915	USFS
Cutthroat	Yellowstone (MBS)	1914	USFS
Lake Trout	Unknown	1920	Unknown[1]
Golden Trout	(California)	1936	WDG
Grayling	Unknown	1945	WDG
Steelhead	Coastal / Puget Sound	1916	Unknown[2]
Atlantic Salmon	Unknown	1975	WDG
Brown Trout	Unknown	1935	WDG
Coho Salmon	(Coastal/P. Snd. presumed)	1918	USFS
Chinook Salmon	Wallace (Skykomish) River	1999	WDFW

[1] Source: Piper & Taft (1925); probably USFS.
[2] Source: Trail Blazers, Inc. database; probably USFS.

A wide variety of rainbow trout, including winter-run steelhead, have been stocked. Only the Kamloops variety is known to reproduce in Washington high lakes. Several other varieties (Entiat, Shasta) were obtained from federal hatcheries between 1970 and 1990, and were experimentally stocked to evaluate their growth and performance in an extremely limited number of lakes.

Millions of cutthroat fry have been stocked into scores of different high lakes, most of which were of the Twin Lakes (westslope) variety (Plate 57). As a result, the range of this strain has been artificially extended in Washington (Behnke 1992; Williams 1999). Coastal cutthroat (Plate 57), generally of the Tokul Creek variety (originally from Lake Whatcom), are the second most-stocked variety. A small number of lakes have received Yellowstone Lake and Henry's Lake cutthroat; a few lakes have developed naturalized populations of this strain.

Plate 57. Coastal cutthroat (top fish) and a west slope cutthroat (bottom, flipping fish) illustrate the difference in spotting pattern between these varieties. (23 October 1977) Gerry Ring Erickson photo.

Brown trout have been stocked on a very limited, experimental basis, primarily to test their ability to serve as a top predator, and control stunted fish populations (see Section 5.7.2). The Ford Hatchery stock (Scottish Loch Levan variety) is believed to be the only one that has been used.

Lake trout were introduced into Washington high lakes very early, with the first introduction to Lake Isobell (sic) in Snohomish County apparently occurring in 1920 (Piper & Taft, Inc. 1925). Another naturalized population exists in Eightmile Lake in Chelan County. They have been tested on an extremely limited basis (two lakes) since 1980 for biological control purposes.

Grayling were stocked in Washington in a number of locations as early as the 1920s, but only survive in one (high) lake in Skagit County. Attempts were made in the late 1980s to develop a high lake near North Bend as a grayling brood stock lake, and several fry introductions were made. The effort failed due to predation by the wild rainbow reproducing in the lake. There is currently no brood stock in Washington, nor plans to develop one.

Kokanee were stocked in numerous high lakes in the early 20th century, but their use essentially ceased by 1950. They established reproducing populations in many lakes (see Section 5.7.2). They are only occasionally stocked now, primarily to augment forage for lake trout in one or two lakes.

Atlantic salmon have been tested in a number of high lakes. Results have either been spectacular, or dismal failures. When stocked into barren waters, they exhibit excellent growth, and superb sporting qualities. However, when forced to compete with other species, particularly rainbow, they tend to do very poorly (Plate 42; Williams 1974).

Golden trout (Plate 58) have been stocked intermittently since 1938 (Figure 15). Inconsistent availability of eggs from other western states, particularly after 1970, was recognized as a major problem with this species. When eggs were available, up to 27 lakes were stocked (Figure 16) in as many as 10 counties.

Early efforts by WDG biologist Jim Cummins in the late 1970s to develop a broodstock led to some success in the early to mid-1980s (Pfeifer 1986b). Most of the credit for this measured success was due to the care, attention, and problem-solving of Manager Larry Klube and the staff of the Tokul Creek Hatchery, near Snoqualmie, Washington. A statewide survey of WDG district biologists by Cummins led to the development of an annual statewide fry production goal of 12 to 15,000 fry. Golden trout successfully reproduce in less than five high lakes in Washington. One is stocked with a low number of fry annually to serve as a potential backup source of gametes in case of failure of the captive broodstock, and an inability to import eyed eggs. Gametes have been collected from ripening goldens in a Washington high lake on several occasions.

Figure 15. Number of Golden Trout Stocked into Washington High Lakes and the Number of Counties Receiving Golden Trout, by Year, 1938 to 2000.

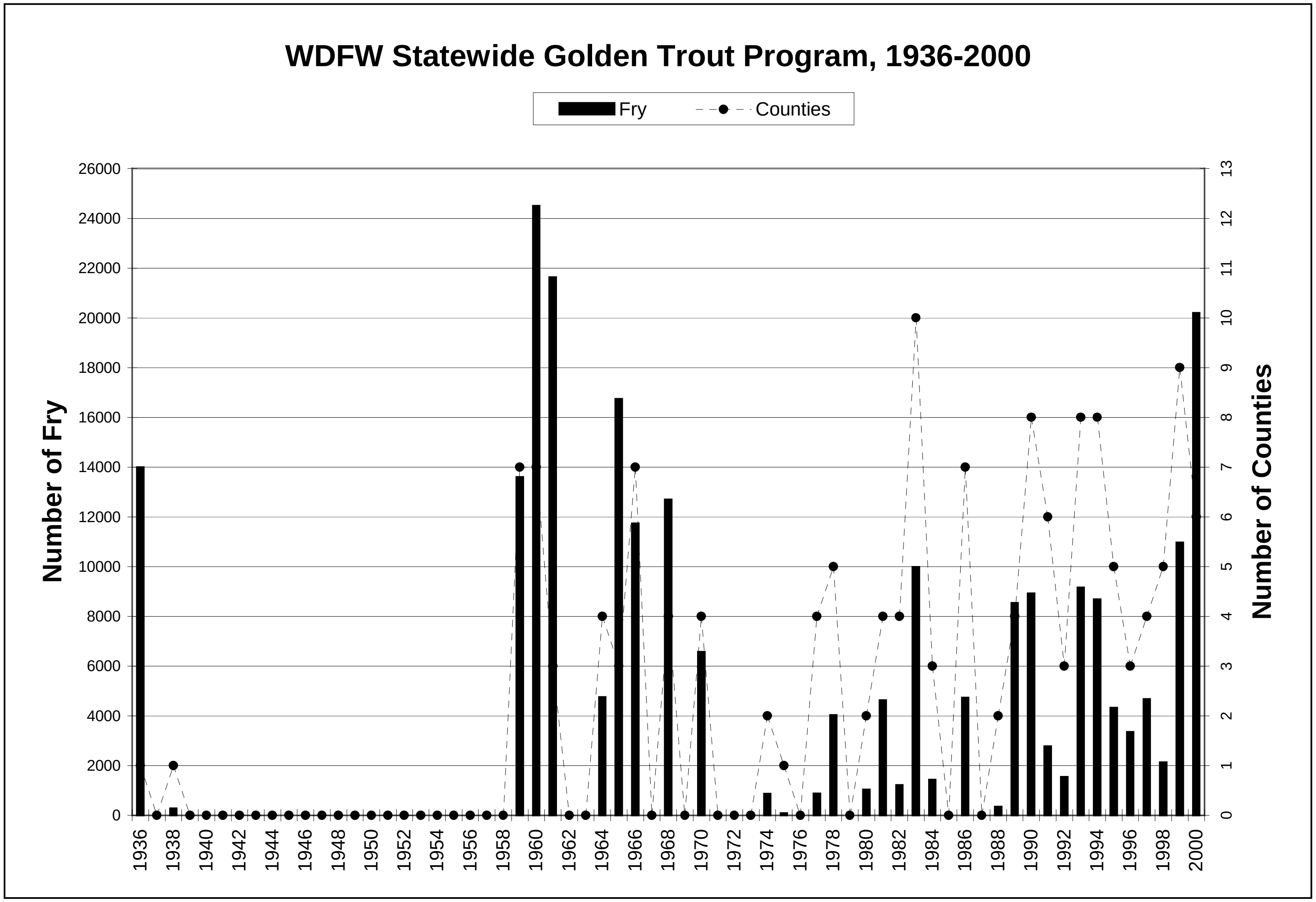
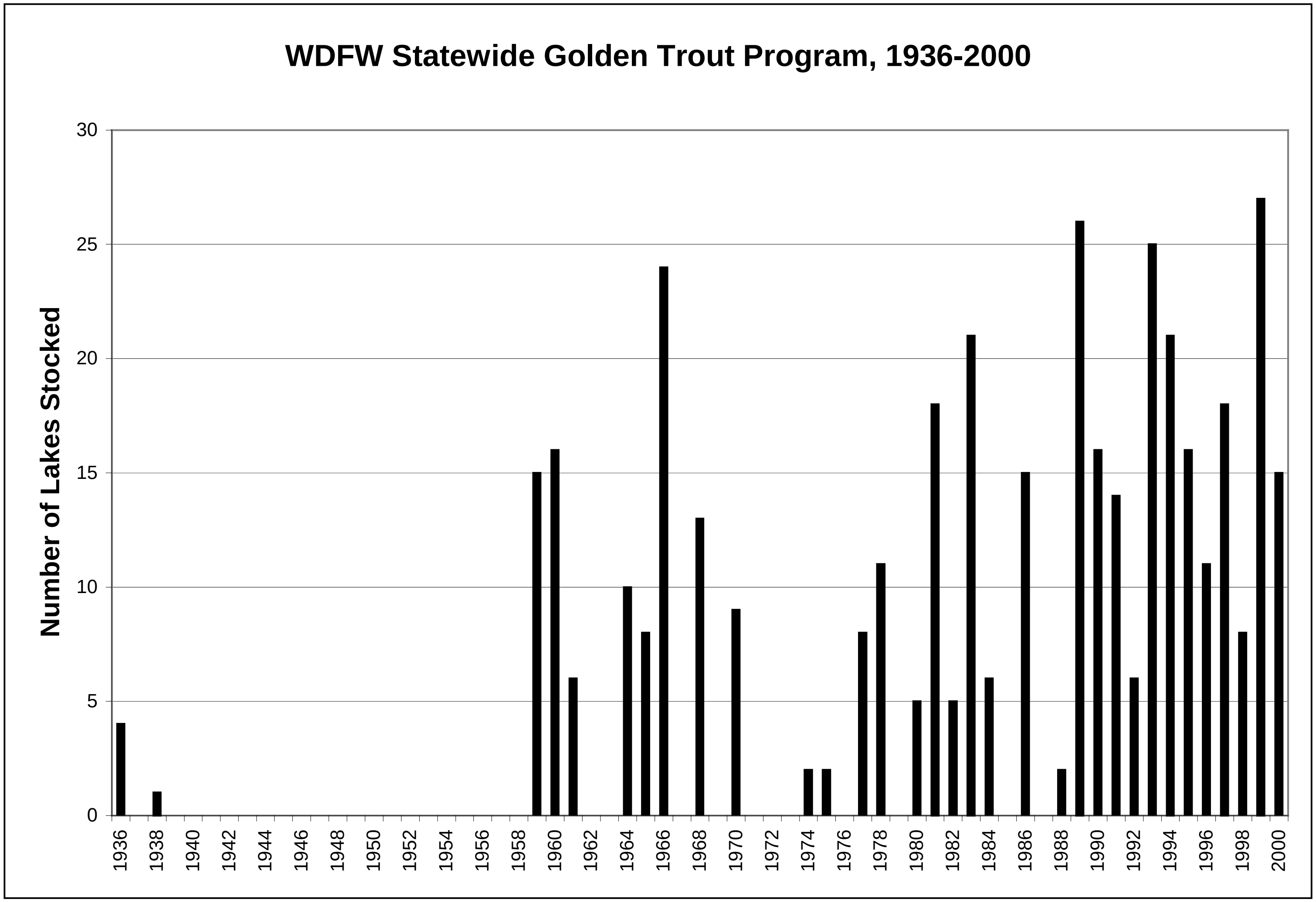


Figure 16. The Number of Washington High Lakes Receiving Golden Trout, by Year, 1936 to 2000.



Chinook salmon are currently being tested as a potential top predator on stunted eastern brook trout in one lake in the Skykomish River drainage. The chinook stock being used is native to the lake's watershed.

5.5.3 Broodstocks and Broodstock Lakes

Native kokanee have been cultured at Lake Whatcom, near Acme, Washington since 1915 (Crawford 1979), and this stock was subsequently introduced to many Washington high lakes. This stock is still occasionally used (previous section), although it was not developed expressly for use in high lakes.

The Mount Whitney rainbow (Crawford 1979) has been a mainstay of the Washington high lake stocking program since the 1960s. Its December to March, but primarily January maturation timing is ideal for producing fry of a size suitable for back packing early in the stocking season. Of greatest importance is the fact that the stock shows very little tendency to successfully reproduce in the high lake environment (Crawford [1979] was in error on this point). The stock is currently maintained at the WDFW Eells Springs Hatchery, near Shelton, Washington.

One of the earliest, and still operating wilderness egg-taking stations was developed on Upper Twin Lake, near Leavenworth (Plate 59 and Figure 17). Westslope cutthroat, native to Lake Chelan, if not the Twin Lakes themselves (Behnke 1992; Crawford 1979), have been spawned at this station since 1915 (Plates 60 to 62). The Twin Lakes have been closed to fishing for decades, and remain one of the few true broodstock lakes in the Washington inland trout program. Recent westslope cutthroat supplementation efforts in the Lake Chelan drainage emphasize the importance of this station and this stock, whose genetic purity has been maintained for 86 years.

The Tokul Creek cutthroat, derived in the mid-1940s from native cutthroat in Lake Whatcom (Crawford 1979), was held at the Tokul Creek Hatchery for about 50 years. The broodstock was moved to the Eells Springs Hatchery along with the Mount Whitney rainbow due to pathological concerns with the water supply at Tokul Creek. The coastal variety (Plate 57) has had limited use in Washington's high lakes, primarily because of its mid-winter spawn timing which produces fry that are generally too large for backpack stocking. Concerns about the use of westslope cutthroat in western Washington will likely result in increased use of the Tokul Creek stock, although neither are genetically identical to cutthroat that may be found in individual streams to which the lakes drain (Campton 1982).

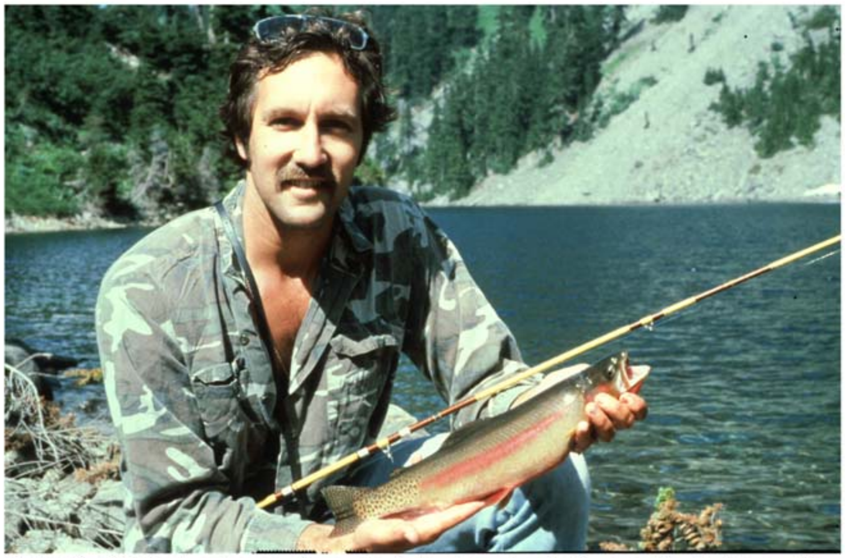


Plate 58. Golden trout engender angler interest well out of proportion to the number of lakes they are found in. This classic example of the strain is from a lake in the Middle Fork Snoqualmie River drainage. (August 1979) Jim Cummins photo.

Plate 59. The original work cabin situated between the Twin Lakes was rebuilt in 1949. The facility is operated soon after the lakes clear, usually in mid-May to early June, until the completion of egg takes roughly one month later. (June 1982)

Figure 17. Location of the WDFW Twin Lakes Eyeing Station Near Leavenworth, Washington.

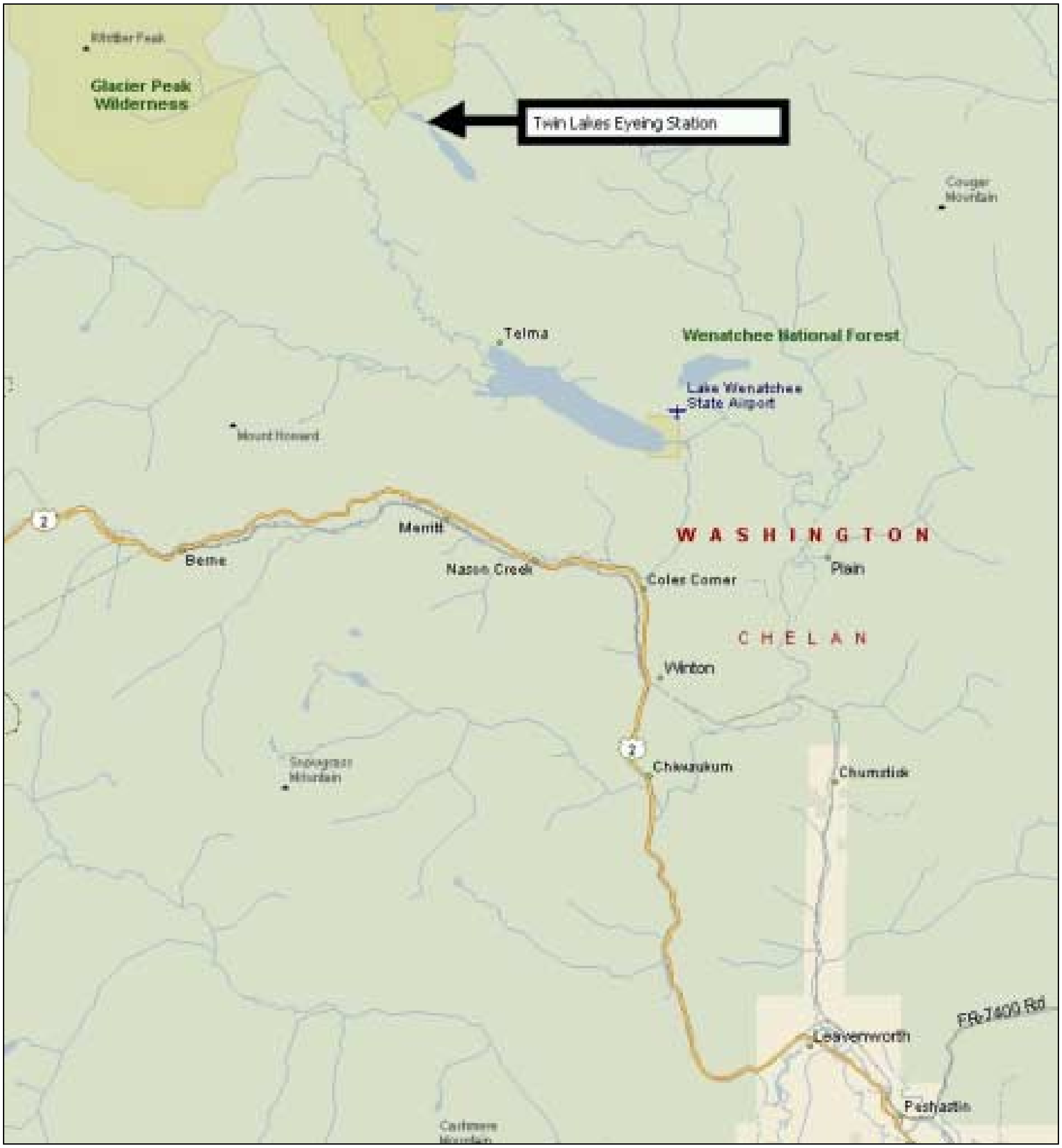


Plate 60. A weir and fyke trap (plus holding box) is situated on the outlet of the upper lake (that forms a low gradient, interconnecting stream to the lower lake). Fish from the upper lake that attempt to spawn in the outlet are collected in the fyke trap. The Welsh corgi sits on the lid of the fyke trap. A biologist transfers fish to the holding box that have been brought from one of the upper lake tributary traps. Fish are spawned about twice a week. (23 May 1993) G. Ring Erickson photo.

Plate 61. The Lynx Creek trap is one of two tributary traps on Upper, or Big Twin Lake. Migrants are ferried in a sedating anesthetic solution to the outlet holding box, where they are checked for ripeness, and ultimately spawned. (23 May 1993) G. Ring Erickson photo.

Plate 62. The District Fish Biologist (left) and local Fish Pathologist spawn Twin Lakes cutthroat from the holding box on one of the two spawning days during the week. This venerable procedure has been conducted at this site since 1915 (Crawford 1979). (June 1982)

5.5.4 Exotic Species

Strictly speaking, virtually all fish stocked into Washington's high lakes are exotic to the lakes themselves since the vast majority of the lakes were fishless since the last glaciation (see Section 2.0). The next level of concern is whether the fish stocked are native to the lake basin, or watershed to which it drains. Again, all stocks used are non-native, except when Twin Lakes cutthroat are stocked into lakes that drain to the mid- to upper Columbia River. These concerns are largely academic unless there is reason to believe the fish will either find their way out of the lakes into which they are stocked, or careless individuals transfer them into other systems supporting native fish.

Diversity of angling opportunity is a goal of the high lake fishery program, and local WDFW managers abide by the agency's Exotic Species Policy. This policy dictates that no species be introduced into waters in which it has not been stocked before unless the State Environmental Policy Act (SEPA) is followed (submittal of Environmental Checklist and biological justifications). WDFW is generally not introducing new species into the high lakes. Where new species introductions are proposed, SEPA guidelines are followed. In general, and as a practical matter, no species is introduced that has the potential of hybridizing or competing with native fish in downstream receiving waters. Stocking non-native species or strains into remote lakes with no surface outlet poses little or no risk to native fish of Washington. And, the history of exotic species stocking in the high lakes is one of very low numbers in a relatively small number of lakes (Table 20).

Table 20. Counties and Number of Lakes Where Unusual Fish Species or Strains Have Been Introduced to Washington High Lakes as of 2001 (Documented Introductions, Only).

Species	Counties	Year/s of Introductions	Number of Lakes Receiving Species or Strain
Eastern brook	Clallam, Jefferson, Mason, Whatcom, Skagit, Snohomish, King, Pierce, Cowlitz, Lewis, Skamania, Yakima, Kittitas, Chelan, Okanogan	1914 - 2000	1399
Yellowstone Cutthroat	King, Kittitas, Lewis, Okanogan, Pierce, Skagit, Snohomish, Whatcom	1914 - 1976	148[1]
Lake Trout	Chelan, King, Snohomish	1920 - 1999	5
Golden Trout	Chelan, Kittitas, King, Lewis, Okanogan, Snohomish, Skagit, Whatcom, Yakima, Mason, Skamania, Jefferson	1936 - 2000	231
Grayling	King, Skagit	1945 - 1986	14
Atlantic salmon	Jefferson, Snohomish, Yakima	1975 – 1985	10
Brown Trout	King, Chelan, Cowlitz, Lewis, Pierce, Skamania, Yakima, Whatcom	1935 – 2000	143
Kokanee	King, Skagit, Snohomish	1917 - 1998	3
Coho Salmon	King, Okanogan, Skamania, Yakima	1918 - 1997	8
Chinook Salmon	King	1999	1

[1] Includes Henry Lake cutthroat.

For the purpose of this report section, rainbow and cutthroat are considered native species. It is generally recognized that Twin Lakes (westslope) cutthroat are genetically dissimilar from coastal cutthroat in western Washington. Similarly, Mount Whitney rainbow can be genetically distinguished from virtually all native rainbow and steelhead in Washington. The balance of this section discusses species that are either not naturally found in Washington, are not found in the lake's watershed, or both.

Experimentation with brown trout as a biological control of stunted fish continues in a very small number of high lakes. No new lakes are currently being proposed to receive this species. (Biological control of stunted fish is a major area of interest [see Section 5.7.2]. Reports of success with tiger muskies (a hybrid cross between muskellunge and northern pike) as a control of stunted eastern brook trout in Idaho high lakes are extremely encouraging (see Section 5.7.2.3), and may lead to some similar testing with this sterile hybrid in Washington.)

Interest in the use of arctic grayling in a few lakes remains high among WDFW local managers (Parametrix 2001). The managers continue to receive calls from the public asking about the singular population, and whether WDFW will expand use of this species. Any new introductions will require a full SEPA review.

Although there are no current plans to stock atlantic salmon, their spectacular performance in at least one Olympic Peninsula Lake in the 1970s makes them a good candidate for very limited use in selected lakes lacking a surface outlet. Their unusual appearance (Plates 41, 42), not to mention their tendency to repeatedly leap clear of the water, often generates calls to the local management biologist when they are encountered in the high country.

5.5.5 Assessment and Recommendations

Overall stocking has been declining for the past 20 years. Most lakes are on low-density, maintenance stocking programs. Recent concern about potential genetic impacts on native fish in streams below high lakes is well-intentioned. However, with rare exceptions, the concern has not been validated by any evidence that significant competition or hybridization is occurring anywhere in Washington with native fish below stocked lakes. The source of exotic species or strains in outlet systems is usually made obscure by historic stocking practices or long histories of both legal and illegal stocking affecting both streams and lakes. Diversity and maximization of recreational angling opportunity are goals of the high lake fishery program (WDG 1981; WDFW 1995a). Species are generally not being stocked into lakes where they have not been stocked before; new introductions are subject to a full SEPA review process.

Recommendation #1: Exotic species such as brown trout, lake trout, atlantic salmon, tiger muskies, and grayling should be stocked where special circumstances make sound biological sense to do so. Many lakes with stunted trout and char populations cannot be treated with piscicides. They must either remain as is, or potentially receive benefits from a biological control such as a top predator. Unusual species which attract high angler interest (golden trout, grayling) should be expanded to a low number of lakes lacking surface outlets if their introduction does not result in unacceptable impacts from increased recreational use.

Recommendation #2: As a general rule, species should be stocked that are native to the lake's drainage basin (e.g. rainbow, cutthroat). To maintain program diversity, strains that are not having a negative effect on native biota (e.g. golden trout) should continue to be stocked.

5.6 ECOLOGICAL CONSIDERATIONS

WDFW fishery managers are aware of the need to consider the ecological effects of the high lake stocking program. As noted in earlier sections, the overall number of lakes being stocked is dropping (Figure 3), as is the general density of fry stocked (Figure 4). The Fish and Wildlife Commission mandate is to "Maximize recreational opportunity for fish and wildlife constituents consistent with the preservation, protection, and perpetuation of the fish and **wildlife** resources" (WDFW 1995a). The native invertebrate and amphibian members of the communities associated with sub-alpine and alpine lakes are classified as **wildlife** (RCW 77.08.010 (16)), therefore their protection and preservation is explicitly directed in Commission policy.

5.6.1 Amphibian and Invertebrate Impacts

There is substantial international concern over the loss of amphibian species, and the possible causes (Barinaga 1990; Pechmann and Wilbur 1994; Blaustein and Wake 1995; Koch et al. 1997). (The stocking of trout into mountain lakes has been suggested as a mode of transfer of *Saprolegnia spp*., a ubiquitous fungus found in virtually all open, natural waters. It has been further suggested that such transfers have lead to amphibian mortality from *Saprolegnia*. This is a specious hypothesis; see Appendix H.) Some of the most recent research suggests a variety of factors, linked to the recent changes in climate, may be responsible for amphibian die-offs (Kiesecker et al. 2001). WDFW fishery managers are equally concerned about the possible effect of stocked trout on native amphibians and invertebrates in Washington, and conducted a detailed review of the literature on the subject (Divens et al. 2001). What follows is a concise summary of that review; readers with a strong interest in the ecological effects of fish in high lakes are urged to read the full report, as well as many of the papers reviewed, in order to gain a full understanding of this complex subject.

5.6.1.1 *Amphibians*

There is no evidence that any amphibian native to the subalpine and alpine zone in Washington has suffered substantial population declines, or is in danger of extinction. Most concern expressed about the effects of Washington's high lake program on amphibians is based on research conducted in other states. The only published research on the interaction of fish and amphibians in Washington high lakes is that which has been conducted in the North Cascades National Park (Liss et al. 1995). That study did not provide any evidence that stocked trout have eliminated amphibians over any significant portion of their natural range. The study did, however, reaffirm findings common to studies from other states. The most important of these is the observed negative correlation between salmonid density and amphibian larval density within their study lakes.

The effects of trout or char on amphibians are species-specific and life history dependant, and vary depending on the species of fish, fish density, and the reproductive capability of the fish species introduced. Important abiotic factors affecting amphibian larval survival include lake morphometry and habitat characteristics, and amphibian habitat that is unavailable to trout within the same drainage basin. In plain terms, some amphibian species are more vulnerable to trout or char predation than others; in Washington, long-toed salamander (*Ambystoma macrodactylum*) appears to be most vulnerable (Divens et al. 2001). Amphibian larvae become difficult or impossible to find or collect when fish densities exceed about 250 fish per surface acre (Hoffman and Pilliod 1999; Divens et al. 2001). This negative relationship tends to weaken when lakes are more productive (higher nutrient levels)(Tyler et al. 1998), or when there is in-lake refugia in the form of shallow edges, or abundant woody debris or talus interstices to serve as cover for larval salamanders (Liss et al. 1995). Ponds and wetlands proximal to lakes supporting trout or char can serve as alternate breeding and overwintering habitat, preserving a nucleus of vulnerable species (e.g., *A. macrodactylum*) in lake basins where fish are excessively abundant.

Seven salamander species occur in Washington's high mountain areas. Three species, northwestern salamander (*Ambystoma gracile),* long-toed salamander, and roughskin newt (*Taricha granulosa*), breed in lakes or ponds. The roughskin newt and northwestern salamander possess protective secretions, and co-exist with trout and char in Washington's high lakes (Table 7). Long-toed salamander is likely more susceptible to predation, as indirectly shown by studies in Washington (Liss et al. 1995). However, long-toed salamanders are widespread throughout many habitat types in Washington, from western coastal lowlands, to eastern shrub-steppe, to high mountain areas. While their density can be significantly lower in lakes with high density trout or char populations, the effects of trout stocking on their abundance and distribution on a basin or regional scale remain unknown (Divens et al. 2001).

Of six frog and toad species found in Washington's high country, only one, the Columbia spotted frog (*Rana luteiventris*), may potentially be more vulnerable to trout predation in stocked high lakes than other Washington frogs. Unlike Washington's other high mountain anurans, tadpoles of this species may overwinter in deeper lakes or ponds at high elevations and metamorphose the following spring (Nussbaum *et al.* 1983; Corkran and Thoms 1996). However, Columbia spotted frogs have been found to coexist with trout in basins and even lakes with stocked trout as they typically utilize littoral and wetland habitat inaccessible to trout. In Washington, this species occurs in eastern parts of the Cascade Mountains and in low elevation areas of eastern Washington (Green et al. 1997). Koch et al. (1997) reported that the Columbia spotted frog appears to be widespread and common in the main portion of its range, including eastern Washington.

Despite examining the contents of thousands of stomachs from trout collected from Washington high lakes, none of the WDFW fish biologists have seen evidence of frogs or tadpoles in trout diets. On the other hand, larvae and adults of some salamanders, particularly *A. gracile*, are commonly eaten. Empirical observations suggest that larger larvae and adults are not preyed upon by trout until they reach about 12 inches in total length, or an age of about 3 years (WDFW file data). Thus, in lakes where single age classes of fish mature and die from introductions as fry, there are periods of up to several years where amphibians are presumably able to co-exist with younger trout, experiencing little or no predation. This is supported by research in other states that clearly shows co-existence of salamanders with trout, usually under conditions of low trout density (Divens et al. 2001).

After surveying scores of subalpine and alpine lakes in King and Snohomish County over 15 or more years, WDFW Area Biologist Bob Pfeifer noted the common co-existence of *A. gracile* with trout in lakes that have been managed on a cyclic, low-density stocking regime for many years, or decades (Table 7). Similar information was not obtained for long-toed salamander (*A. macrodactylum*) in this district, although this species is significantly more difficult to observe and survey (Divens et al. 2001).

A general conclusion of a thorough review of the literature on the subject of trout and salamander interactions in Washington high lakes (Divens et al. 2001) is that trout and salamanders are able to co-exist when trout or char numbers are kept low. Unfortunately, most researchers investigating these interactions failed to note fish densities in their study lakes. A general trend gleaned from the studies is that salamanders are able to co-exist with trout and char when the fish populations are maintained by periodic stocking, and at levels at or below 100 fish per surface acre (Divens et al. 2001). Most of the studies that exhibited significant impacts to salamanders came from waters that held fish at levels well above this density.

5.6.1.2 *Invertebrates*

There is little doubt that introduced trout can alter both the abundance and community structure of zooplankton and macroinvertebrates in stocked high mountain lakes, especially if the fish population is dense. However, population densities of even vulnerable invertebrate species have often been reported to rebound in lakes as fish abundance declines, or when fish are eliminated (Bahls 1990). Mechanisms facilitating the rebound process are not always clear, but likely involve either immigration (Maguire 1963; McNaught et al. 1999), reproduction by individuals that escaped predation and detection during sampling (Kiser et al. 1963; Nilsson and Pejler 1973), or a combination of both. Recolonization, the ability of zooplankton to utilize fishless lakes, refuge habitat within stocked lakes, and lakes with low density fish populations, apparently allow these species to persist in geographic areas with stocked trout. In some extreme instances, recolonization may not occur due to the biotic and abiotic changes which can arise following the introduction of trout to a previously fishless high mountain lake. Based on recent data, in zooplankton communities in Washington high lakes managed for fisheries, extirpations, if any, are most likely to occur in lakes with reproducing trout or char, resulting in high fish densities. It is unknown whether trout stocked in Washington have eliminated any zooplankton species. However, if such a situation were identified in Washington, there is reported evidence that once an undesirable fish population is eliminated by management action, a zooplankton community can probably be restored by re-introduction of those species which fail to re-appear (McNaught et al. 1999).

5.6.1.3 *Summary*

Washington fishery managers are aware of the problems associated with excessively abundant trout and char in high lakes, and began experiments with biological controls as early as 1979 (see Section 5.7.2). Whole-lake chemical treatment with rotenone was used on a stunted eastern brook trout population in Olympic National Forest in 1973 (Johnston 1973). A two-lake fish removal project was proposed in the Henry M. Jackson Wilderness in 1983 (Weinheimer and Kearney 1983), but was not carried out due to funding difficulties. Federal and state land and fishery managers are using both rotenone and Antimycin piscicides in stunted char removal projects in western states, including Washington (Mottram 1995; Fraley 1996; Drake and Naiman 2001). WDFW fishery managers are wholly supportive of efforts to restore balance to the many aquatic communities in Washington's high country that have been impacted by excessively reproducing fish populations. One option to restore quality fisheries and ecological balance is by removing problem species or strains and replacing them with species or strains that can be maintained at low density through disciplined stocking.

Research reviewed by Divens et al. (2001) indicates that the degree of impact stocked trout may have on native biota inhabiting high lakes can vary widely. To date, no research has focused on determining the impact of various trout species or stocking rates typically used in high lake stocking. Although some researchers have reported that stocked trout caused a decline in the abundance of some native species, other research suggests that there may be little effect using certain management strategies (i.e., certain trout species or stocking rates and cycles). Studies on the impacts on non-fish species have tended to lump fish species, and rarely provided detailed information on the actual density of fish present in study lakes.

Some researchers have recommended halting high lakes stocking and leaving only "wild" fish populations that can sustain themselves through natural reproduction (Bahls 1990; Murray and Boyd 1996; Munger et al. 1997). Following this recommendation, WDFW fishery managers could offer only lakes with introduced self-reproducing fish populations. Lakes with reproducing fish populations have been reported most likely to have an impact on native biota. Additionally, these lakes often offer less desirable trout populations for anglers because of their tendency to over-populate and stunt. Elimination of the more desirable fisheries will also increase the tendency of unscrupulous or ignorant publics to transfer problem trout or char species from these lakes to other waters, thereby exacerbating and extending the potential impacts of such reproducing populations.

The WDFW literature review (Divens et al. 2001) shows that the high lake fisheries likely to have the least impact on the native biota and offer "quality" fishing opportunities are put, grow and take populations maintained by stocking select species of trout at low densities on a schedule that keeps the number of fish in the lake below that which threatens native biota. Long term experience by local WDFW fishery managers suggests stocking rates of 100 fish per surface acre or less are compatible with native amphibians and conspicuous macrozooplankton (Table 7). Research is needed to determine with more rigor which stocking density should be used to provide diverse recreational fishing opportunities, while at the same time ensuring the persistence of native lake fauna. Specific research along these lines is suggested in Divens et al. (2001).

5.6.2 Native Fish Impacts

Introduced fish can impact native fish species in many ways including genetic, inter- and intra-specific competition, and predation (Krueger and May 1991; Philipp et al. 1993; Kitano et al. 1994). Because most high lakes in Washington were historically fishless, there have been few sites where stocked trout have interacted directly with native fishes. However, emigration of trout from high lakes into connected streams can occur. Most problems with dropout from high lakes and competition or hybridization with downstream native fish seem to involve brook trout. Brook trout stocked directly into lakes and streams inhabited by bull trout have competed with, or hybridized with, bull trout populations in Washington and other western states (Leary et al. 1983; Leary and Allendorf 1991; Buktenica 1997). In Colorado, native greenback cutthroat trout (*Oncorhynchus clarki stomias*) inhabiting streams below stocked high lakes were displaced by naturally reproducing brook trout (Windell and Foster 1982). Considering the downstream barrier to fish passage, Windell and Foster (1982) believed the brook trout originated in the high lakes upstream. Following their stocking in Beaver Lake, in north central Washington, brook trout colonized Beaver Creek below, resulting in the extirpation of native bull trout in at least the south fork (Ken Williams, WDFW District Fish Biologist, unpublished data).

Although introduced fish can displace native fish species in streams through hybridization and/or competition, the extent of emigration of stocked trout from high lakes in Washington to streams above and below stocked lakes is unknown. Nevertheless, many local WDFW fish managers are cognizant of these risks, and either use native fish stocks in their high lake program, or consciously avoid use of species known to contribute to this problem (Parametrix 2001). There is currently a virtual moratorium on the stocking of eastern brook trout into Washington high lakes. Most WDFW local managers would also like to have the resources to begin a systematic program of removing reproducing eastern brook trout (and certain westslope cutthroat) populations – the ones most likely to be emigrating from high lakes and interacting with downstream native fish. Finally, the use of exotic fish species in Washington high lakes is generally limited to those with no surface outlet, or where experience with low density populations in the lakes has not revealed an emigration problem.

5.6.3 Wildlife Benefits

Carnivorous wildlife benefit from fish introductions into formerly barren lakes, although the evidence of this is mostly anecdotal. WDFW local fish biologists and high lake anglers have seen fish taken from high lakes by mergansers and ospreys (Curtis and Erickson 1992). An active osprey nest was observed by WDFW biologist Bob Pfeifer adjacent Upper Tuscohatchie Lake in King County, while surveying it in 1991. It is reasonable to expect species such as raccoon, coyote, otter, fisher, marten, and black bear to take fish either from the lakes directly, or more likely from spawning tributaries, particularly when the fish are exhausted after spawning. This food source may be increasingly important as their foraging range outside designated wilderness continues to shrink due to an ever-increasing human population, particularly in the western Cascades.

5.6.4 Habitat Protection

WDFW Fishery and Habitat Biologists have very limited control or influence over actions taken by major timber owners, or federal land managers. An estimated 46% of "high" waters >0.1 acre in Washington are located in designated wilderness (Table 17), and upland habitat around the lake is generally well-protected, except for the incidental impact of recreational users. In some areas high lakes occur on lands owned by major timber companies, or on state land administered by the Washington Department of Natural Resources (DNR). Coordination between WDFW biologists and timber/land managers from DNR and private owners can sometimes protect nearshore habitat through elements of the Washington Forest Practices Act (RCW 76.09).

Unfortunately, state law has often been inadequate to protect the natural forest or meadow environment surrounding some high lakes (Plates 63 through 68). The impact of clear-cutting around a 19-acre lake is not limited to aesthetics (Plate 63), but can affect the lake's thermal regime, particularly for shallow lakes (Plates 65, 66). Altered rates of snow accumulation and snowmelt due to removal of the forest in the lakebasin may also alter the annual water budget (Rothacher 1970). Again, the impact would be expected to be greatest on small, shallow lakes. The ecological effects of these perturbations have not been extensively studied in Washington high lakes. However, research in a natural, uncut subalpine lake ecosystem showed that needle drop and other allochthonous sources of carbon can be a major part of the lake's carbon budget, much of which supports the invertebrate (fish food) community (Wissmar et al. (1977). These authors stated that their "study illustrates the probable dependence of many lakes in coniferous forests upon allochthonous inputs and their sensitivity to land-based perturbations".

Plate 63. Almost no trees were left standing when clearcut logging occurred around 19-acre Nadeau Lake, near North Bend in the early 1980s. The old growth forest had shaded out most understory. Three outstanding fisheries were lost when three large lakes within a square-mile Section received this treatment and access was gated off. It will be many decades before the original aesthetics and local carbon pathways are restored. (28 May 1983)

Plate 64. A "buffer strip" one or two trees wide was left along 5-acre Rachor Lake, near North Bend. However, such strips commonly blow down, eliminating all shade benefits, and effectively extinguish normal allochthonous carbon input from needle drop. Trees which topple into the lake offer some substrate value for invertebrates, but often inhibit fishing. (28 May 1986)

Plate 65. Small lakes such as Upper Mine Creek Pothole (South Fork Snoqualmie River drainage) are exposed to unusual rates of heating when forest cover is removed. Exposure to ultraviolet radiation and lake heating may also affect amphibian reproductive success. (26 June 1990)

Plate 66. Broad, shallow meadow lakes such as Airplane Lake in the lower Skykomish River drainage are also vulnerable to heating when the large cedars that occurred around the lake are removed. Manipulations of the woody debris at the lake's outlet by users of the logging road that crosses it has resulted in a serious drop in lake elevation. It can no longer support a fishery due to exposure and shallowness. (23 May 1995)

Plate 67. Removal of a beaver dam on the outlet of Lower Duffey Lake (lower Skykomish River drainage) lowered the lake several feet. Former productive, shallow, rush-filled bays are now exposed, and the lake's overall area has been substantially reduced. Fish, amphibian, and wildlife habitat has been lost. Logging is currently occurring around both Lower and Upper Duffey Lakes. (20 July 1998).

Plate 68. Logging roads near lakes often provide irresistible temptation to off-road vehicle users. This chronic muddy mess extends to the edge of Rockdale Lake, near Snoqualmie Pass, as well as to its principal inlet. (2 July 1998)

5.6.5 ESA Coordination

There has been very little application of the Endangered Species Act (ESA) to the WDFW high lake program to date. As mentioned in Section 5.6.3, the presence of fish in many high lakes probably provides a potential additional food source for species such as bald eagle, gray wolf, and grizzly bear. Human interactions with spotted owl and marbled murrelet may be problematic in nesting areas, but fishing is rarely the sole reason people go to high lakes (Hendee et al. 1977). WDFW fishery managers have worked cooperatively with wildlife and recreation managers in instances where backcountry users conflict with sensitive species such as wolves or loons. Adjustment of access and fishing season opening dates are one method used to minimize conflicts in certain locales.

Dropout of eastern brook trout from high lakes into streams with native bull trout is an obvious ESA issue, and was discussed in Section 5.6.2. WDFW does not stock eastern brook trout into high lakes with surface outlets that drain to basins that currently or historically supported bull trout. WDFW would like to have the time and resources to begin a systematic program of removing (and in most cases, replacing with an appropriate substitute fish species or sterile strain) eastern brook populations from high lakes that drain to bull trout habitat.

Apart from eastern brook trout fallout, there is no known problem or potential problem with the high lake program and other listed fish species, such as Puget Sound chinook, or mid-Columbia River salmon and steelhead.

Use of bull trout as an apex predator to control stunted brook trout, Kamloops rainbow, or westslope cutthroat (see Section 5.7.2) may provide an opportunity to restore bull trout presence in basins from which they have been extirpated, or to simply extend their range and overall numbers (Pister 1990).

5.6.6 Assessment and Recommendations

WDFW fishery managers are cognizant of the ecological interaction issues surrounding the historic high lake fishery, and future stocking. Stocking rates and cycles have been adjusted downward for nearly 30 years, with the largest adjustment occurring in the early 1970s. A detailed literature review confirmed that WDFW's program of maintaining low-density, quality-oriented fish populations in a limited number of waters is consistent with the protection of native amphibians and invertebrates. Positive steps have been taken in the past to remove problem fish populations, and this program should be expanded to one of reclamation of at least several lakes annually. This would have two major benefits:

- Positive progress in removing fish populations known or likely to have ill effects on native fish, amphibians, or invertebrates; and

- Assurance that WDFW maintains a fisheries management field staff experienced and expert in the chemical or biological treatment of lakes having problem fish populations.

Impacts of the historic and current high lake stocking program on native fish are poorly documented. Better information is needed on the rate and extent of fish dropout from high lake – which species, what age or sizes, and under what conditions. Problem lakes with eastern brook (or other species) that threaten native species such as bull trout should be prioritized for chemical or biological control treatments.

Recommendation #1: The prioritized research topics listed in Divens et al. (2001) should be implemented as budgets allow. Fish should be removed from lakes where they are documented to have an unacceptable impact on native species. Conversely, fish should be allowed to remain in lakes where they have historically provided a valuable recreational fishery and potential wildlife benefits, and where they are not having an unacceptable impact on native species.

Recommendation #2: For ecological as well as angling quality reasons, lakes that require stocking should be stocked at low densities, and on an infrequent basis to keep overall fish abundance low. In general, native fish species that do not reproduce should be used (see Section 5.4.7).

Recommendation #3: A list should be prepared of all known Washington high lakes that contain excessively abundant fish populations (most are known, and local WDFW file data should enable this). The lakes should be prioritized for treatment (partial or complete fish removal, or biological controls), and the suggested treatment/s noted for each lake. Criteria for prioritization are social (recreation benefits), physical (logistics and site-specific conditions; costs), and ecological (degree of current impacts, fish species involved, etc.). For each lake, fish removal or numbers reduction actions that are feasible should be identified.

5.7 POPULATION CONTROL METHODS

To date, WDFW has primarily used chemical methods (rotenone) to control or eliminate excessively abundant fish populations in Washington high lakes. Although this should probably occur on scores of high lakes statewide, it has only been attempted (and successfully accomplished) on one lake in the Olympic Mountains (Johnston 1973). Local fishery managers, often in cooperation with sports groups, have conducted very limited experimentation with hybrid trout and top predators, but none of these tests have (yet) resulted in major reductions in fish abundance that are needed to assure native invertebrate communities are not significantly less diverse than the natural, fishless condition. Neither liberalized regulations nor intensive fishing have been tested by WDFW. These options are further discussed, below.

5.7.1 Chemical Methods

Unfortunately, the prospect of use of any chemicals in the seemingly “pristine” environments that typically surround high lakes often elicits strong emotions from publics who are not familiar with the specific properties of the piscicides. Erroneous, misleading, and fear-promoting misinformation as to alleged properties of chemicals such as rotenone often require professional organizations and agencies to publish reports and articles in an attempt to correct the damage (Bradbury 1986; Task Force on Fishery Chemicals 2001). Rarely, if ever, are the short term effects of rotenone or Antimycin publicly balanced against the benefits of removing excessively abundant fish that are exerting a continuous predatory and competitive force on native biota. (The economic and recreational benefits are well-published [Ball 1945; Trimberger 1975; Stockbridge 1977; WDG 1979; Christenson et al. 1982; Bradbury 1986], even if not publicly well-known.)

Public awareness needs to be raised of the benefits to be gained by removing problem fish populations. These benefits include restoration of the native invertebrate community (Kiser et al. 1963; Anderson 1970), and replacement of a stunted, unattractive fish population with a healthy, fast-growing population in balance with its environment (Johnston 1973; Walters and Vincent 1973; Fraley 1996). The common fear of “chemicals in the water” needs to be balanced with facts; rotenone has commonly been used to control problem fish in public drinking water supplies (Cohen et al. 1960).

Chemical treatment options are limited to rotenone, or Antimycin (Schnick et al. 1986). While rotenone has been used very successfully in high lakes (Fraley 1996), even in Washington (Johnston 1973), its impact on non-target species (i.e., invertebrates) is longer-lasting and more severe than Antimycin. (However, its use still does not result in extinctions [Bradbury 1986].) In fact, when Antimycin is used at the levels needed to eradicate fish, “generally there were no discernible effects on invertebrates” (Schnick 1974). Antimycin is almost certainly the chemical of choice, particularly if the lake has a flowing outlet. Applied in parts per billion, much smaller quantities of active ingredient are required to treat a given volume of water. Its toxicity is measured in hours or days (Gresswell 1991), rather than weeks, or even months (Anderson 1970; Engstrom-Heg and Colesante 1979). Its greatest value lies in the fact that it is extremely rapidly degraded when in contact with sunlight and strong oxygenation. Therefore, high lakes with steep, dashing outlets do not require chemical treatment (Pfeifer 1985) to detoxify the chemical before it reaches downstream fish populations (Tiffan and Bergersen 1996). Rosenlund and Stevens (1992) removed eastern brook from 26 lakes and streams in Colorado, including waters in Rocky Mountain National Park, and verified the “natural degradation of Antimycin in stream habitats with an elevation loss of 260 to 490 feet”. These authors reported case histories where eastern brook have been eliminated for over 15 years.

Federal land managers have used piscicides to remove unwanted fish populations for years (Gresswell 1991; Rosenlund and Stevens 1992), including lakes in Washington (Mottram 1995). WDFW fishery managers have decades of experience in application of piscicides (Bradbury 1986). Only a lack of resources has prevented WDFW biologists from extending their experience to problem populations in more high lakes (Johnston 1973; Weinheimer and Kearney 1983).

5.7.2 Biological Controls

Use of top predators to control smaller prey species, yet provide angling opportunity is a common tool in warmwater fisheries (McCammon and von Geldern, Jr. 1979). Generally, use of non-native species should be approached with extreme caution; use of sterile hybrids or neutered fish are safer approaches (Everhart et al. 1975). Since it was obvious that rotenone could not be used in all high lakes having stunted eastern brook populations, WDFW high lake fishery managers became interested in top predators as an alternative control method in the mid- to late 1970s. While top predators and hybrid trout competitors have been tested in numerous high lakes in both western and eastern Washington (Pfeifer 1995), data were only available from the following three lakes, and serve as examples of the range of results that may be expected. (The results of the experiments in these three lakes will be the subject of separate, more detailed technical reports. These results are purposefully reported without customary statistical analysis.)

It is useful to establish some measures of success where the fishery management goal is to improve on adverse conditions in a fish population, rather than eliminate the population and start over. The paramount goal is to reduce problem fish numbers. Incidental benefits include improved growth rates and fish condition. Since WDFW local managers rarely have the resources to perform mark-recapture studies to obtain fairly accurate population estimates (Gresswell et al. 1997), reduced fish abundance in the three experimental lakes can be inferred if catch per unit effort (cpue) from a standardized gill net set drops appreciably, and consistently. Corroborating evidence of reduced fish density includes increased length at age, and increased relative weight, a standardized measure (Anderson and Nuemann 1996), and internal body fat (a subjective measure). Finally, in most cases, the management “bottom line”, assuming a fish population is to be retained in a lake, is to improve the quality of the fishery. Improved quality can take the form of increased diversity, such as when a new species is introduced for control purposes, but which can also be caught (Tipping 1996). Most anglers also are interested in catching and keeping a few fish of nice size and condition (Braaten 1970; Moeller and Engelken 1972). These indices were used to evaluate the success of top predator introductions in the three test lakes.

5.7.2.1 *Top Predators*

Unnamed Lake

In 1979, 200 Age 1 brown trout were stocked by helicopter with a fire bucket into a 23-acre lake located at 4500-ft in the Skykomish River drainage (Plates 69, 70), resulting in a density of 8.7 brown trout per surface acre. (The lake is not named herein because of the likely publicity this report will receive, and the potential increased impact on the lake environment due to notoriety.) The purpose of this introduction was to attempt to reduce the abundance of the severely stunted, naturally-reproducing eastern brook trout population (Plate 71). Periodic monitoring in 1980 and later years indicated the brown trout, which had been reared in a hatchery raceway for over a year, had difficulty adapting to the natural environment. Many grew slowly, if at all (Plates 72, 73), and some became emaciated. Some fish were presumably able to successfully switch to a diet of fish, as they grew to large size and maintained good to excellent condition (Plate 74). Most of these survivors were difficult to catch, and lived for 8 to 10 years.

The high mortality and poor condition seen in the brown trout stocked as yearlings led to a change in the stocking strategy to one of backpack stocking advanced fry, or small fingerlings. Two supplemental brown trout introductions into Unnamed Lake occurred in 1990 (500 at 60/lb) and 1994 (300 at 150/lb). If a mortality rate of 50 percent is assumed in the first year after stocking (Donald and Alger 1986), a density of 10.8 browns per acre existed in 1991, and approximately 15 per acre in 1995.

Table 21 summarize most of the success indices following WDG biologist Jim Cummins' pioneering introductions in 1979. In 1977, Jim described the fish as "extremely thin", and "severely stunted" (Plate 71). In 1996, two remarkable fish were collected. An 18 inch specimen was in excellent condition (Wr = 96.6), and had heavy internal fat. A second 11.6 inch fish was also in good condition. These were the largest brook trout reported from this lake in nearly 50 years of angler reports. Discounting the obviously faster-growing fish in 1996 (Table 21), the maximum size observed in all eastern brook samples increased slightly by 1998, adding one half inch since 1977. Length at age in 1998 was slightly higher than in 1977 for Age 3 fish, and 0.8 inch greater for Age 4 brook trout. Unfortunately, weights were not taken on the char before the brown trout were added in 1979. However, relative weight showed an increase between 1996 and 1998 for fish collected at the same time of year (fall), again excepting the unusually large specimen.

Plate 69. Unnamed Lake (shaded, at photo bottom) in the Skykomish River drainage. The frozen lake at left center does not drain to Unnamed Lake. (18 July 1995)

Plate 70. Unnamed Lake has long been popular with local hiker/campers. Heavy use was probably driven more by the aesthetics of the area then the opportunity to fish the stunted eastern brook trout population. (26 July 1980)

Table 21. Matrix of Eastern Brook Population Indices in Three Western Washington High Lakes Stocked with Top Predators, 1977-1999

Lake	Year	Overnight Gill Net Set cpue	Relative Weight	Maximum Length (in)	Length at Age 2	Length at Age 3	Length at Age 4
Unnamed	1977		ND	9.25		7.0	7.5
Unnamed	1996		96.6	18.0	8.6	10.0	11.8
Unnamed	1996	1.49	80.6	9.9			
Unnamed	1998	0.88	83.8	9.8	5.4	7.2	8.3
Talapus	1981			10.4			
Talapus	1984	2.875	84.4	13.3			7.0
Talapus	1988	0.765	90.1	9.3			
Talapus	1989	2.625	86.3	9.8	6.2	8.1	8.7
Talapus	1991	1.600	89.5	10.3	5.5	8.0	9.3
Talapus	1999	0.750	86.3	10.2			
Pratt	1984	2.471	87.7	9.5			
Pratt[1]	1992	0.583	88.2	9.8			8.8
Pratt[1]	1997	0.700	90.6	10.2	5.6	7.1	9.0
Pratt[1]	1998	0.479	83.1	10.3		7.6	9.7
Pratt	1999		86.0	10.2			
Pratt	2001		86.6	11.4			

[1] Length at age estimated; total ages from otoliths only.

Plate 71. This emaciated eastern brook trout from Unnamed Lake looks more like a deep-sea swallower (Family Eurypharyngidae) than a healthy char. Large numbers of starving fish can be expected to reduce many members of the lake's native invertebrate community to undetectable levels. (26 July 1980) Jim Cummins photo.

Plate 72. Two-year old brown trout that had been stocked as yearlings into Unnamed Lake in 1979 were in relatively poor condition the following year. (26 July 1980) Jim Cummins photo.

Plate 73. Although the brown trout were by no means prime in 1980, some anglers were nevertheless thrilled at the opportunity to find fish of even this size and condition in Unnamed Lake after decades of stunted brook trout. (26 July 1980) Jim Cummins photo.

Plate 74. Some brown trout stocked into Unnamed Lake in 1990 were 25 inches long in 1998, and weighed almost 8 pounds. The fish was in excellent condition. (7 October 1998)

A large majority of the brook trout in Unnamed Lake now have trace or light amounts of internal fat (Table 22), whereas in 1977 none of the 20 fish sampled by Cummins had any internal fat. Conditions continued to improve in 1998, where over one quarter of the fish sampled had moderate amounts of internal fat.

Although the same gear was set at the same time of year in the same locations, gill net cpue for brook trout dropped 41% between 1996 and 1998 (Table 21). Finally, the general size distribution and maximum length of the brook trout in Unnamed Lake changed for the better between 1977 and 1996 (Figure 18).

These indices all suggest brook trout abundance has dropped in Unnamed Lake since the brown trout stocking program began. Predation on smaller brook trout is presumed to be a major factor, since all brown trout collected during sampling in 1996 had small brook trout remains in their stomachs (Plate 75). While the brown trout have obviously not eliminated brook trout in Unnamed Lake, they have added a definite element of diversity and quality to the catch (Plates 74, 75). However, improvements in the brook trout population are slow, and measured. As recently as 1993 some of the char were still thin (Plate 30), but none of the fish sampled in 1996 or 1998 had this appearance (Plate 75).

Table 22. Subjective Ratings of Internal Body Fat in Eastern Brook Trout From Talapus and Pratt Lakes, Washington, 1977- 2000

			Subjective Internal Fat Content (%)			
Lake	Year	Number of Eastern Brook	None	Light	Moderate	Heavy
Unnamed	1977	20	20 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Unnamed	1996	18	2 (11.1)	15 (83.3)	0 (0.0)	1 (5.6)
Unnamed	1998	15	2 (13.3)	9 (60.0)	4 (26.7)	0 (0.0)
Talapus	1988	10	0 (0.0)	8 (80.0)	2 (20.0)	0 (0.0)
Talapus	1989	20	1 (5.0)	17 (85.0)	2 (10.0)	0 (0.0)
Talapus	1991	8	3 (37.5)	4 (50.0)	1 (12.5)	0 (0.0)
Talapus	1999	9	2 (22.2)	6 (66.7)	1 (11.1)	0 (0.0)
Pratt	1981	4	4 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
Pratt	1992	8	1 (12.5)	5 (62.5)	2 (25.0)	0 (0.0)
Pratt	1997	25	2 (8.0)	19 (76.0)	4 (16.0)	0 (0.0)
Pratt	1998	30	1 (3.3)	29 (96.7)	0 (0.0)	0 (0.0)
Pratt	2000	8	0 (0.0)	7 (87.5)	1 (12.5)	0 (0.0)

Light = Fat in continuous streaks, but of minimal depth (< 1 mm).

Moderate = Fat continuous, depths ranging from 1 to 2 mm; organs, stomach, and intestine generally visible.

Heavy = Fat generally > 2 mm in thickness; organs, stomach and intestine generally occluded, and only visible by teasing apart fat accumulations.

Figure 18. Length Frequency of Unnamed Lake Eastern Brook Trout, 1977 – 1998.

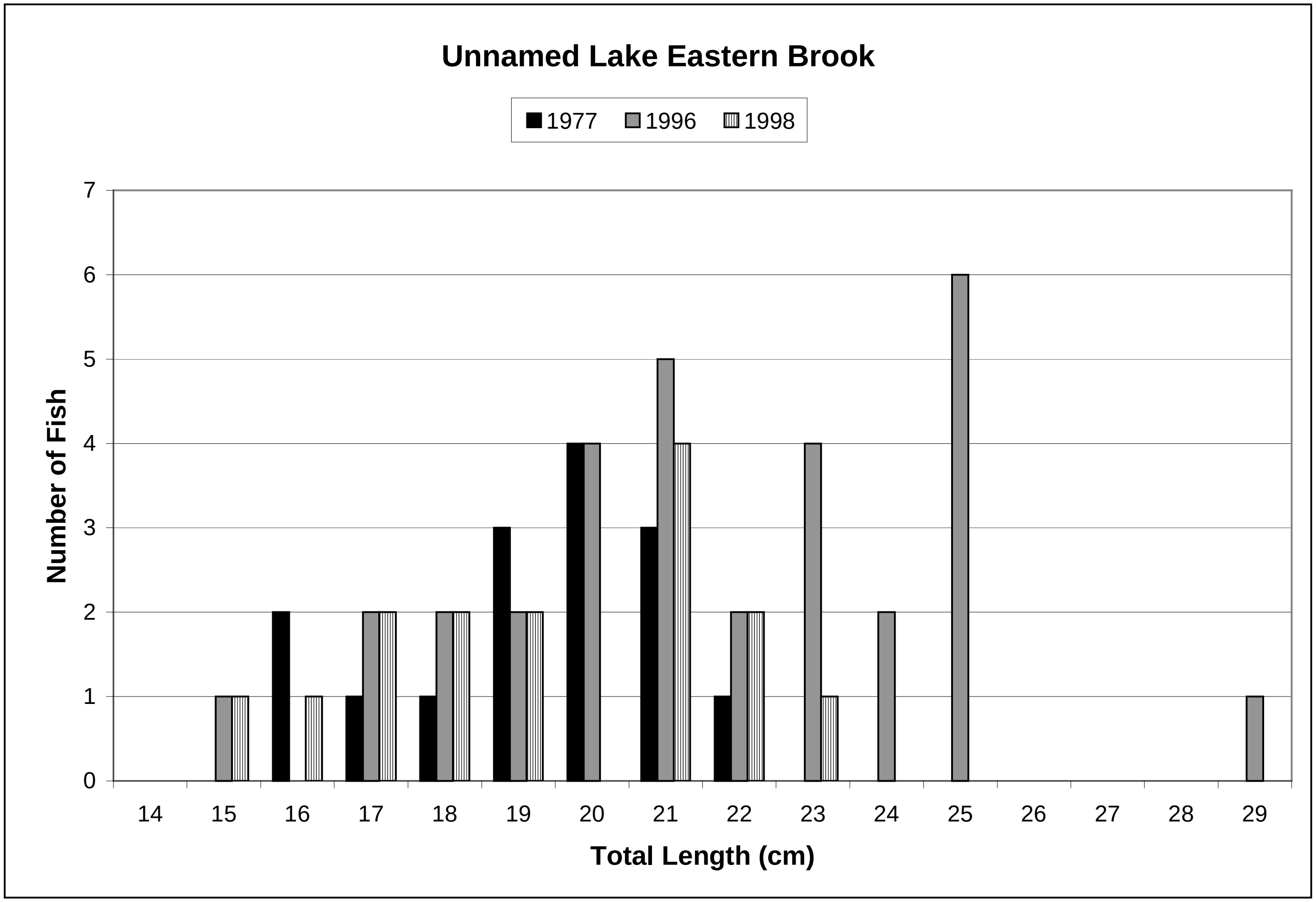


Plate 75. Mixed eastern brook and brown trout from Unnamed Lake, September 27, 1996. All of the brown trout, which were running about 11.5 inches, had eastern brook fry in their stomachs. All of the eastern brook were in good condition.

The Unnamed Lake brown trout experiment can be viewed as a partial success in that it improved several measures of the fishery (quality and diversity of both fish species). A major unknown is the condition of the lake's invertebrate community before and after the putative reduction in char density. The Unnamed Lake experience may be only slightly better than that seen in other lakes where they have been tested; one WDFW high lake manager reported he "got big browns and lots of eastern brook" (Parametrix 2001).

Talapus Lake

A similar test was conducted in 18-acre, 3270-ft Talapus Lake (Plates 76 to 78), a subalpine lake that supports reproducing brook and cutthroat trout. Sub-yearling brown trout running 30 to 40 per pound were backpack stocked at 9 to 11 fish per acre in 1983 and 1984. Supplemental stockings occurred at the same density in 1988, 1989, and 1990. The fish population was sampled with sinking gill nets at the same time of year (early summer), and in the same locations in 1984, 1988, 1989, 1991, and 1999. Results in Talapus were mixed, and certainly not conclusive, except it is clear that the brook trout were not eliminated. The initial condition of the brook trout in Talapus (Plate 79) was also much better than that seen in Unnamed Lake (Plate 71).

There was considerable variability seen in brook trout relative weight between 1984 and 1999 (Table 23), however the relative weight data must be interpreted with caution. Fish condition factors are known to vary with the season and state of sexual maturation (Carlander 1969), and this was certainly observed in Talapus Lake. An attempt was made when sampling all of the test lakes to sample at the same time of year, and when the lakes had been clear of ice for approximately the same amount of time. It was obvious when mid-June samples were collected in 1991 and 1999 that the lake had not been open an equivalent amount of time as the mid-July samples taken in 1984 and 1988. Additional net sets were therefore made in mid-July to coincide with sets made in 1984 and 1988. Brook trout condition improved between mid-June and mid-July in both 1991 and 1999, but especially in 1991. It is interesting to note that the condition of the char was relatively good (Wr = 85.2) even when the lake had just cleared (40^{o} F) in mid-June of 1999. They were in much better condition than a larger fish sample on nearly the same date in 1991, even after one of the heaviest snow packs in many years. Overall, relative weight increased only very slightly between 1984 and 1999 for fish collected in the third week of July (Table 23).

There was no appreciable change in the amount of internal body fat seen between 1988 and 1999, although sample sizes were low (Table 22). The maximum length seen in the brook trout actually occurred in 1984, when a 13.3 inch fish was collected. The largest subsequent fish was 10.2 inches (Table 21 and Figure 19). Gill net cpue was quite variable, but if the low cpue in 1988 is not included, the 11 year series may represent a declining trend from the high value of 2.875 in 1984 to the low of 0.750 in 1999 (Table 21).

The test of top predators in Talapus Lake was confounded by a change in the amount of char spawning habitat due to inlet flooding by new beaver activity (Plate 76). Thus, any change in the condition and abundance of the char could not be ascribed solely to predation since it could also have been associated with reduced fry recruitment. The brook trout population in Talapus was also not in acutely poor condition at the start of the test (Plate 79), unlike Unnamed, and other lakes. Talapus Lake brook trout had an average relative weight of 84.4 in 1984, higher than that seen in Unnamed Lake in 1998, after Unnamed Lake char had improved considerably (Table 23). (By way of perspective, the severely stunted brook char in Tye and Joan Lakes (Plates 80 and 36) had relative weights of 76.6 and 74.7, respectively.)


Plate 76. The inlet system just west of Talapus Lake had flooded a sizable area, and consisted of multiple slow channels due to beaver activity in the mid-1980s. The view is to the northwest just west of the lake. The amount of former spawning habitat that had been flooded is unknown. (16 July 1991)


Plate 77. The main inlet of Talapus Lake forms a peninsula at the lake's west end. (16 July 1991)

Plate 78. View northeasterly of the main body of Talapus Lake in the South Fork Snoqualmie River drainage. There are several very small trickle tributaries on the north shore, but they offer very little spawning habitat. (16 July 1991)

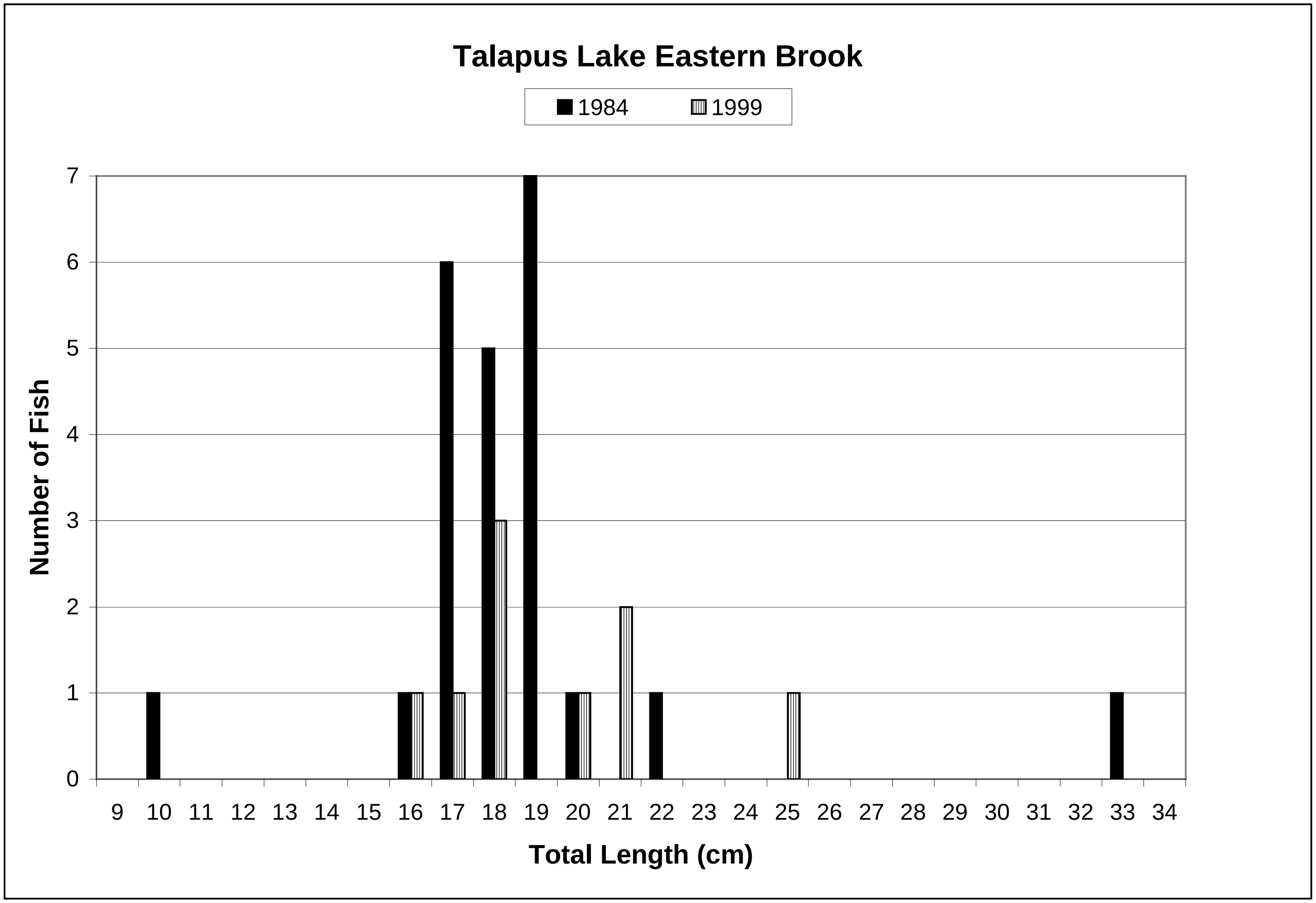
Plate 79. Seven eastern brook, one cutthroat, and four brown trout collected from Talapus Lake on June 20, 1991 (counterclockwise from top left). The length and age of the brown trout were 7.5 inches, Age 2; 8.25 inches, Age 3; and 11.6 inches, Age 8.

Plate 80. Eastern brook trout collected from Tye Lake on September 13, 1995. Note the very poor condition of the top and fifth fish. The fish were 3 to 6 years old.

Table 23. Relative Weights of Eastern Brook from Three Washington High Lakes with Stunted Populations Treated with Top Predator Biological Controls, 1984-2000

Lake	Year	Date	Sample Size	Lake Temperature (F)	Relative Weight (Wr)
Unnamed	1996	9/27	33	50	81.1
Unnamed	1998	10/7	15	55	83.8
Talapus	1984	7/19	22	60	84.4
Talapus	1988	7/15	10	54	90.1
Talapus	1989	6/16	26	50	86.3
Talapus	1991	6/20	19	50	74.6
Talapus	1991	7/16	5	60	89.5
Talapus	1999	6/26	3	40	85.2
Talapus	1999	7/16	6	54	86.3
Pratt	1984	7/19	20	66	87.7
Pratt	1992	7/3	12	64	88.2
Pratt	1997	7/5	31	62	90.6
Pratt	1998	6/5	30	54	83.1
Pratt	1999	7/13	13	56	86.0
Pratt	2000	6/26	8	61	85.2
Pratt	2001	6/28	7	54	86.6

Figure 19. Length Frequency of Talapus Lake Eastern Brook Trout, 1984 – 1999.



Pratt Lake

A long term experiment with a lake trout introduction has yielded interesting and limited, but positive results. Pratt Lake is a 125-foot deep, glacially-carved lake in the west-central Cascades (Plate 81). Inlet and shoreline-spawning brook trout were thin, with large heads in 1984 in the 43.5 acre lake. Lake trout averaging 45 per pound were backpack stocked in 1985 in a long-term test of their ability to improve the condition and size of the eastern brook. The initial introduction was 15.1 lake trout per surface acre.

Eastern brook relative weights from Pratt Lake must be interpreted with caution, just as in Talapus Lake, since the length of time the lake had been clear of ice when the population was sampled varied from year to year. A slight increasing trend in relative weight is seen between the years 1984 and 1997 when all of the net sets were made in early to mid-July (Table 23). Sampling in 1998, 1999, 2000, and 2001 was consciously arranged to try to be at the lake as soon after iceout as possible in order to increase the chances of sampling the lake trout. The lake was still fairly cold, and had not been open long in 1998, 1999, and 2001. The year 2000 represents an intermediate condition. More detailed analysis of these data may show that none of the changes in relative weight are statistically significant.

None of the few brook trout caught on hook and line in 1981 had any internal body fat, but this could have been partly due to the low sample size. By 1992, over 87 percent of the 25 sampled char had light to moderate internal fat deposits (Table 22). A more substantial sample in 1997 verified that a majority of the eastern brook now came through the winter with at least light to moderate fat reserves. This trend continued through 2000. (Fish were not sampled for internal fat in 2001.)

Growth rate (length at age) was not available from the 1981 or 1984 brook trout samples (the scales from these fish are also very difficult to read). Length at age increased annually between 1992 and 1998, and represents some of the higher growth rates among the three experimental lakes (Table 21). The average length of age 4 brook trout from Pratt Lake (9.7 inches) is now the highest value seen in these populations, with the exception of the unusually large fish collected from Unnamed Lake in 1996. The maximum size observed in the brook trout has increased from 9.5 inches in 1984 to 11.4 inches in 2001 (Table 21 and Figure 20).

Growth rates observed in Pratt Lake are intermediate in the range seen among Washington high lakes. Eastern brook thrive in many high lakes of the southern Cascades, where stunting is not as ubiquitous (Plate 43). A good example of excellent brook trout growth is seen in Elochoman Lake in Cowlitz County (Table 24). At the other extreme are lakes such as Tye, Mazama, and Upper Twin, which typify the classic stunted fish that plague many of our high lakes in Washington. These fish continue to live and exert predatory pressure on a lake's invertebrate food resources for many years, sometimes to an almost unbelievable extent (Reimers 1979).

There are two fairly strong lines of evidence that overall fish abundance is reduced in Pratt Lake following the lake trout introduction. Eastern brook catch per unit effort from a standardized net set dropped from 2.50 in 1984 to 0.875 in 1997, and 0.75 in 1998. Second, and most interesting, is the fact that kokanee, which were initially introduced into Pratt Lake by the U.S. Forest Service in 1918, were not being caught by anglers, and were totally absent from the angler catch report record which began in 1968 for this lake. No kokanee were taken in four floating and sinking gill net sets in three separate years (1981, 1984, 1992). These sets yielded a total of 38 brook trout. However, sampling by both gill net and hook-and-line in 1997 found kokanee readily catchable; subsequent high lake anglers who visited the lake out of curiosity about this turn of events also had no difficulty catching kokanee along with the brook trout. The lake has been monitored annually since 1997, and both kokanee and brook trout can now be caught from shore or raft.

Plate 81. Pratt Lake in the Pratt River (Middle Fork Snoqualmie River) drainage, looking north. (August 1976) Jim Cummins photo.

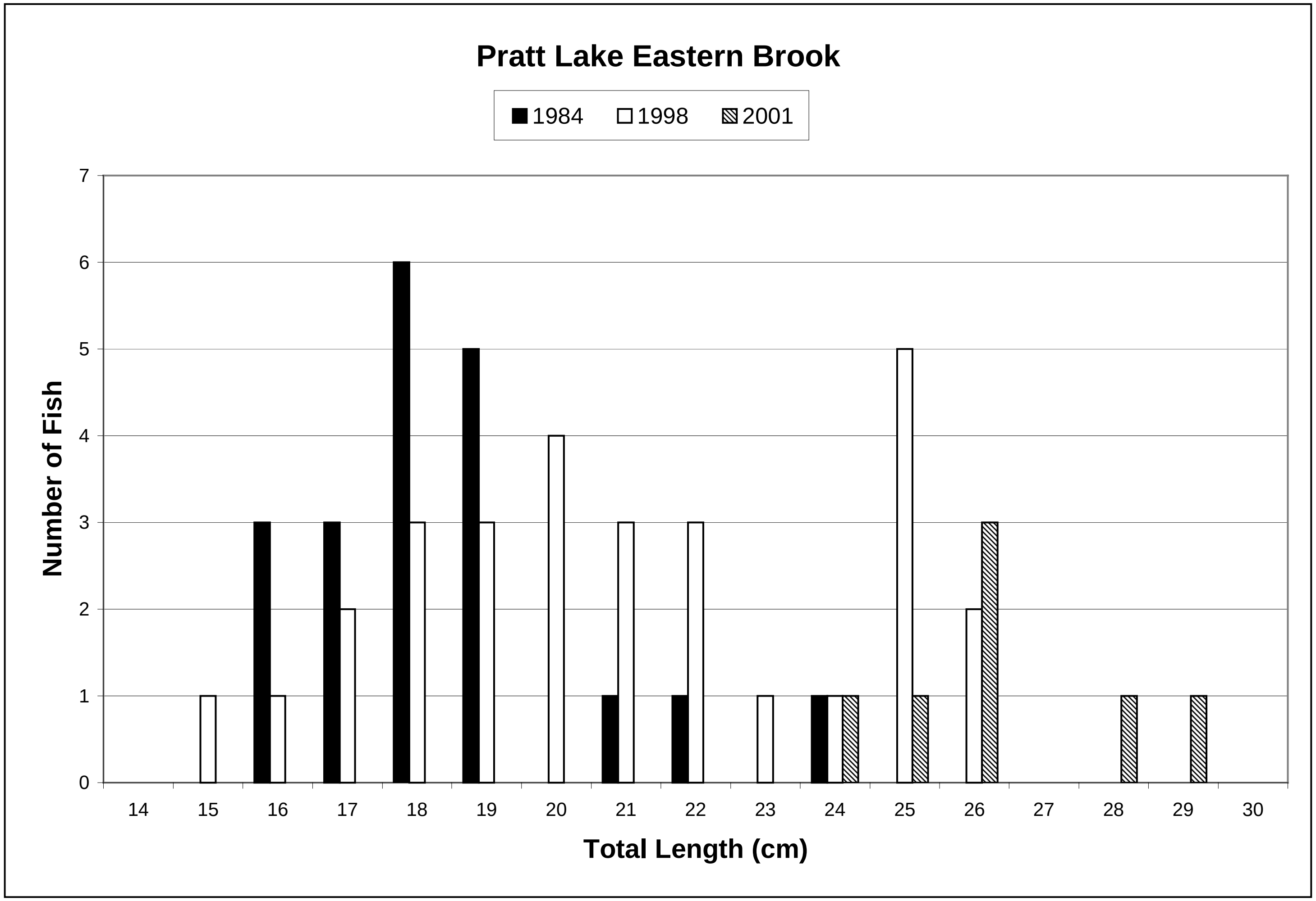


Figure 20. **Length Frequency of Pratt Lake Eastern Brook Trout, 1984 – 2001**

Table 24. Comparison of Pratt Lake Eastern Brook Mean Total Length (Mm) at Age with Other Washington High Lake Brook Trout Populations Of Greater Or Lesser Growth Rate.

			Mean Total Length at Age				
Growth Rate	**Lake**	**County**	**Age 2**	**Age 3**	**Age 4**	**Age 5**	**Age 6**
Fast	Elochoman	Cowlitz	9.8	11.5			
Intermediate	Pratt (‘81)	King			8.4	9.7	
Intermediate	Pratt (‘98)	King		7.6	9.7		
Intermediate	Iceberg	Whatcom		7.9	10.4		
Intermediate	Granite	Lewis	7.4	8.5	11.0		
Slow	Tye	King		6.6	6.7	7.4	7.6
Slow	Mazama	Whatcom			5.6		
Slow	Upper Twin	Whatcom		5.5	6.1		

Perhaps the most significant change in the Pratt Lake fishery, apart from being able to catch three species now instead of one, and for fish which are no longer stunted and in poor condition, is the ability to catch fish up to at least 19 inches (Plate 82). This fish, plus one other lake trout taken in 1997, both aged to the 1985 brood year. This fishery is now significantly improved over one where angler reports referred to “small”, “scrawny and lifeless”, and “skinny” fish (Plate 83). However, like Unnamed Lake, there is insufficient information to judge whether the putative reduction in overall fish density has resulted in recovered diversity or abundance in the lake’s zooplankton and invertebrates.

Plate 82. Age 14+, 19 inch lake trout from Pratt Lake, taken on July 13, 1999. Bill Henkel photo.

Plate 83. Eastern brook (two left columns), a 13" lake trout, and kokanee (above lake trout) from Pratt Lake on July 5, 1997. The lake trout was 12+ years old. None of the fish are in poor condition. Bill Henkel photo.

Summary

Table 25 summarizes the eastern brook trout population status indices for Unnamed, Talapus, and Pratt Lakes as of 1999. All indicators showed improvement in Unnamed Lake, but none did in Talapus Lake. In Pratt Lake, all indicators except relative weight improved following the introduction of lake trout in 1984. Talapus Lake brook trout were not in very poor condition at the start of the experiment (Plate 79), and the heavy fishing pressure the lake receives probably resulted in many of the brown trout being caught before they could have much of an effect on the char population. The fisheries in both Unnamed and Pratt Lakes are now significantly improved over what they were in 1979, at almost no cost, apart from the special monitoring which occurred with these tests.

The fisheries in Unnamed and Pratt Lakes should continue to be monitored, and top predators periodically added as needed. (Bull trout would be an excellent alternate predator to test; see next section.) The quality of the brook trout may continue to improve, as well as the size and effectiveness of the top predators.

Table 25. Matrix of eastern brook population indices in three Washington high lakes supplemented with top predators.

	INDICATOR					
Lake	**Faster Growth**	**Increased Relative Weight**	**Reduced CPUE in Standard Gill Net Set**	**Improved Internal Fat Content**	**Increased Length or Growth Rate**	**Increased Fishing Diversity / Quality**
Unnamed	YES	YES	YES	YES	YES	YES
Talapus	NO	NO	NO	NO	NO	NO
Pratt	YES	NO	YES	YES	YES	YES

5.7.2.2 *Other Species*

WDFW managers are interested in experimenting with bull trout or Dolly Varden in high lakes with stunted trout or char. The piscivorous nature of bull trout and Dolly Varden is well-documented in lowland lakes and streams (Thompson and Tufts 1967; Willamette National Forest 1989). Based on limited studies of bull trout ecology in high lakes elsewhere, this species appears to be a potential candidate for experimental use in the role of a top predator (Wilhelm et al. 1999). Use of these native fish for biological control would, in most cases, eliminate concern about dropout or washout into downstream waters, particularly if a stock was used that is native to the lake's watershed. Wilhelm et al. (1999) found that typically vulnerable macroinvertebrates such as *Gammarus,* and large, conspicuous zooplankton such as *Daphnia* were able to coexist with reproducing bull trout up to 21.25 inches in size in Harrison Lake (3.4 acres, max depth 35 feet) in Banff National Park. (Bull trout is the only fish species in the lake.) *Gammarus* and chironomids were the main dietary items, which emphasizes the importance of low fish density and differential diets of young and old fish in maintaining invertebrate communities. The bull trout were piscivorous to only a very limited degree, feeding almost exclusively on the native aquatic invertebrate community. The authors speculated that cannibalism could occur during winter under ice cover when the thick ice and snow cap would displace small fish from the shallow-water refugia.

Limnetic *Daphnia* escaped intense predation because larger bull trout are limnetic in Harrison Lake, and do not choose zooplankton, while younger, smaller bull trout remain in shoreline areas.

5.7.2.3 *Sterile Hybrids*

Although used with significant success in a large lowland reservoir in Washington to control northern pikeminnow (Tipping 1996), tiger muskies, a sterile hybrid, have not been used in Washington high lakes. However, biologists with the Idaho Department of Fish and Game have preliminarily reported a high degree of success in dramatically reducing the abundance of stunted brook trout in a high lake (Ice Lake). A muskie introduction in 1998 has reportedly reduced the brook trout population to the point where they are now difficult to catch with either hook and line or gill net.

Trail Blazers, Inc., with WDFW approval, have experimented with female rainbow and male golden trout in 14 high lake in western and eastern Washington (Pfeifer 1995). Earlier *ad hoc* experiments by the National Marine Fisheries Service with these and similar hybrids in a larger number of lakes suggested that some obscure interspecific behavioral mechanism can lead to dramatic reductions in density of the problem fish species. Follow-up surveys from test introductions made in 1993 and 1995 are being completed in 2001. Data analysis and a technical report are scheduled to follow the third and final follow-up surveys on these 14 lakes.

5.7.3 Intensive Fishing / Regulations

Liberalized regulations have been tested in a few lakes and regions in Washington to control or ameliorate the ill effects of excessively abundant trout or char in high lakes (Merritt and Schaefer Lakes in Chelan County; Spectacle Lake in Kittitas County; Indian Heaven Wilderness in Skamania County). The success or failure of these regulations has not yet been evaluated.

Low-key experiments are underway using volunteers to test for perceptible effects from liberal angling in a few lakes. Evidence of success, if any, would be expected to appear as reduced catch per unit effort and improved fish condition. Preliminary results are not encouraging. Given the reproductive potential of a fish population, assuming good egg-to-fry survival in spawning areas, fishing gear or methods far more efficient than angling are required to effectively reduce the total fish population, particularly where angler access is limited (Le Cren 1965; McFadden et al. 1967; Everhart et al. 1975; Donald and Alger 1986).

Gill nets have sometimes been successfully used to remove all fish from a small lake. Intensive netting would certainly substantially reduce the overall density of a trout or char population, but the effort would need to be repeated periodically to maintain a low population. The effort involved to attain a complete removal is suggested by Kelso and Shuter (1989) who desired to remove about 135 fish which were accidentally released to a 29 acre lake. The fish, a mixture of rainbow trout, brook trout, and lake trout, were not reproducing, ranged in size from 6.3 inches to 24.5 inches, and ranged in age from 1 to 4 years. Three multi-panel gill nets, each 210 feet long, were fished on the lake bottom, with daily changes in location. Twenty eight overnight sets of the three nets were made in the first year, and not all fish were removed. The last of the fish were removed after 12 more sets in the second year. (The netting results were particularly instructive in that no fish were caught on four consecutive nights after the first 20 days of netting, suggesting major depletion. One fish was caught on the 25th night, then 16 were taken on the 26th. Thus, netting efforts would need to continue well beyond the first “null sets” to be sure all fish were removed.)

While intensive netting or trapping may have potential for partial control, or even complete fish removal in lakes where such effort is a high priority, the thousands of man-hours involved to apply this technique to scores of lakes with excessively-abundant, reproducing fish populations is a significant management obstacle. This is particularly true for the many wilderness lakes where access involves arduous cross-country hiking. WDFW has not tested this control option since corporate experience indicates it would only make economic sense for an extremely limited number of relatively small lakes where fish removal was a high priority, and other more economical methods could not be used. The use of volunteers to intensively net a prioritized list of lakes has not been pursued.

5.7.4 Assessment and Recommendations

Only chemical treatment (rotenone) has been shown to eliminate stunted, excessively abundant fish in Washington high lakes. Antimycin is much less toxic to non-target species such as invertebrates and zooplankton, and should be used in lieu of rotenone whenever possible. However, many lakes will remain that for one reason or another cannot be treated with piscicides. While work in an Idaho high lake with tiger muskellunge has shown great promise in dramatically reducing the abundance of brook trout, no top predator has done so in Washington. There is indirect evidence that brown trout and lake trout have some potential to improve the condition of formerly stunted brook trout in two Washington test lakes. These species have shown the ability to grow to relatively large size, and add an important element of diversity and excitement to fisheries that were formerly largely shunned. However, it has not been demonstrated that a fish population reduction caused by top predators has resulted in improved conditions in the zooplankton or invertebrate community. Sterile hybrids have so far not been documented as having an ability to reduce excessively abundant char or trout in Washington.

Recommendation #1: A list of prioritized lakes needing control of excessive fish populations should be prepared (see Section 5.6.6). For each lake, one or more potential control methods should be identified; potential control methods include chemical treatment (Antimycin or rotenone), top predators, spawning habitat exclosure (barriers), or intensive netting or trapping.

Recommendation #2: The use of non-sterile exotic top predators should be limited to lakes where they have no potential for having negative interactions with native fish, and where they may have measured success in improving the overall condition and quality of stunted trout or char. Brown trout and lake trout should not be expected to effect significant changes in stunted fish abundance in less than 10 years (or more). Monitoring should continue on the lakes where test introductions have been made, and where initial results show potential for further measurable improvements. Final monitoring data collection and report preparation should occur on the lakes that have received sterile hybrids.

Recommendation #3: An annual program of high lake rehabilitation is long overdue. The extremely high benefit to cost ratio of this fishery (see Section 4) should be balanced against the cost of fishery recoveries. Annual conversion of several high lakes to quality, low ecological impact fisheries will go far to increase angler satisfaction, and to a lesser degree, angler participation. Rotenone and Antimycin should be used, as appropriate, to effect complete eradication of problem fish populations. Intensive netting or trapping is not likely to be an effective tool except for small, easily accessed lakes. A volunteer work force would likely be needed to implement any significant intensive netting or trapping program.

Recommendation #4: Spawning area exclosure should be tested in a few lakes where the spawning habitat is limited to a few inlets where natural materials can be placed that create barriers to the only effective spawning substrate. In general, this option would be used only if other methods, particularly chemical methods, could not be used, or would likely be ineffective.

Recommendation #5: Liberalized regulations should not be relied upon to make any significant or lasting reduction in overabundant or stunted fish populations.

Recommendation #6: Limnological data should be gathered on lakes that have received test introductions of top predators. Although the pre-test conditions are not known, current or final invertebrate species diversity and abundance can be compared to data from other similar vicinity lakes which do not have excessive fish populations. Lakes proposed for new top predator introductions should have their invertebrate communities thoroughly surveyed prior to the predator introduction to enable a better evaluation of the potential benefits of this technique.

5.8 USER PARTICIPATION & SATISFACTION

WDFW local fishery managers generally do not have access to good data on use levels of their high lakes, whether anglers or users. Usually only regional summaries are available, and they tend to be infrequent, and lacking of specifics on angling use (Wenatchee National Forest and Mt. Baker-Snoqualmie National Forest 1990). Statewide statistics on high lake use are, again, typically broad in nature, and infrequent (WDFW 1996a). An estimated 175,324 anglers fished Washington's high lakes in 1994 (WDFW 1996a). This is a 33.5 percent increase over the pervious use estimate in 1986 (Mongillo and Hahn 1988). A similar 4.19% per annum increase in the last 7 years would translate into 182,666 high lake anglers in Washington in 2001. The 1995 survey also found that the average number of days spent fishing high lakes increased from 6 in 1986, to 7.7 in 1995. If the number of days fished remained at 7.7 in 2001, 182,666 anglers would spend 1,406,528 days enjoying the state's high lake fishery. Even if there were no increase over the 1995 estimate of the number of high lake anglers, about 1,350,000 angler days are being spent at the mountain lakes <u>every</u> <u>year</u>.

There is almost no focusing of survey information beyond the statewide level, however the 1995 survey did find that there was very little difference between eastern and western Washington anglers in the percent of their fishing time spent at high lakes (7.3 and 7.9 percent, respectively). A slightly higher percentage of western Washington anglers (18.6 percent) preferred to fish high lakes than eastern Washington anglers (16.2 percent)(WDFW 1996a).

5.8.1 Catch, Harvest, and Effort Statistics

Most WDFW local managers have to manage with the barest of statistics on catch and angler effort from high lakes on their districts (Parametrix 2001). Occasionally US Forest Service or DNR recreation staffs will develop statistics on specific lakes or trailheads, but even then, anglers are rarely, if ever factored out of the general user population. Earlier studies such as Hendee et al. (1968) are now dated, were based on a very limited number of geographic areas, and did not provide quantitative measures or guidelines to apportion use to individual lakes or watersheds.

Some WDFW local managers have ranked annual angler effort as low, moderate, or high (Lucas 1989; Deleray and Barbee 1992). Others have estimated use on an individual lake basis by personally hiking to them, assessing the access difficulty, enumerating the number of anglers seen at the lake, differentiating weekday effort from weekend and holiday effort, using personal judgment based on past experience, and arriving at an approximation of the number of annual trips made to the lake (Cummins, Johnston, Pfeifer, Williams). This semi-quantitative approach can be calibrated to a very limited degree by making comparisons of the personal use estimates with more quantitative figures obtained by a trailhead survey, or by analysis of the High Lake Fishing Report database. Neither of these approaches has been pursued due to lack of time and resources, and an estimate of angler effort on individual lakes remains one of the most, if not the most serious data gap for local managers.

The revised High Lake Fishing Report form (Appendix D), if filled out properly, can be used to generate catch, effort, cpue, and harvest statistics. The database developed from this form, begun in 1986, now stands at 3848 records, and will be higher by the time this report is published. Table 9 shows the number of records, by county, that have been logged that can generate these statistics. To date this database has not been queried to generate statistics on individual lakes for use by local WDFW managers. The database is maintained by members of the Washington State Hi-Lakers, and Trail Blazers, Inc.

5.8.2 Trip and Fish Goals and Objectives (Quantity, Quality)

Most WDFW local managers have developed, or say they are developing goals and objectives that are tailored to each lake. Most feel this is an important thing to do (Parametrix 2001). This is generally manifested as a list of "management considerations" in lake by lake plans that often lack explicit, measurable objectives, such as a minimum catch success rate (Appendix C). There is general recognition that access and biological conditions at lakes vary too greatly to have single, prescriptive fishery management objectives for all. However, WDFW has not developed agreed-upon general, quantifiable fishery performance goals and objectives for the high lake program overall.

The 1981 Strategic Plan (WDG 1981) stated that "Alpine lakes are generally managed as more of a quality or "blue ribbon" fishery than are lowland lakes or reservoirs". The Goal for the program at that time was "…to increase the diversity and quality of angling opportunity. Emphasis will be on improving those qualitative aspects of diversity that make alpine angling a special outdoor experience". Most managers have addressed this goal by adjusting stocking rates and frequencies downward (see Section 5.4.2). Some managers have implicit, or program-wide objectives such as "managing for a target condition where most trip reports from a lake give 'good' to 'excellent' ratings on trip and fish quality, and most anglers catch at least a few trout" (Parametrix 2001). Some managers have also added species or strains in lakes where it is ecologically safe to do so in order to offer greater program diversity (see Section 5.4.3).

One seasoned manager noted that it is often impossible to control the factors that impact the quality of a fishing experience. Examples are crowding, excessive fish reproduction, and the behavior of other anglers. He sagely noted that "we could do more if we can remove or control stunted populations".

Achieving "quality" or "blue-ribbon" performance from a fishery obviously depends on a person's definition of quality. There are, and probably always will be many high lakes in Washington with reproducing trout or char that provide fast fishing action for small fish. Many users find these perfectly acceptable, if not preferable conditions for "family" outings where children get their first mountain fishing experience. WDFW managers recognize the need to provide this aspect of the fishery, as long as it is not harmful to the general aquatic ecology of an area.

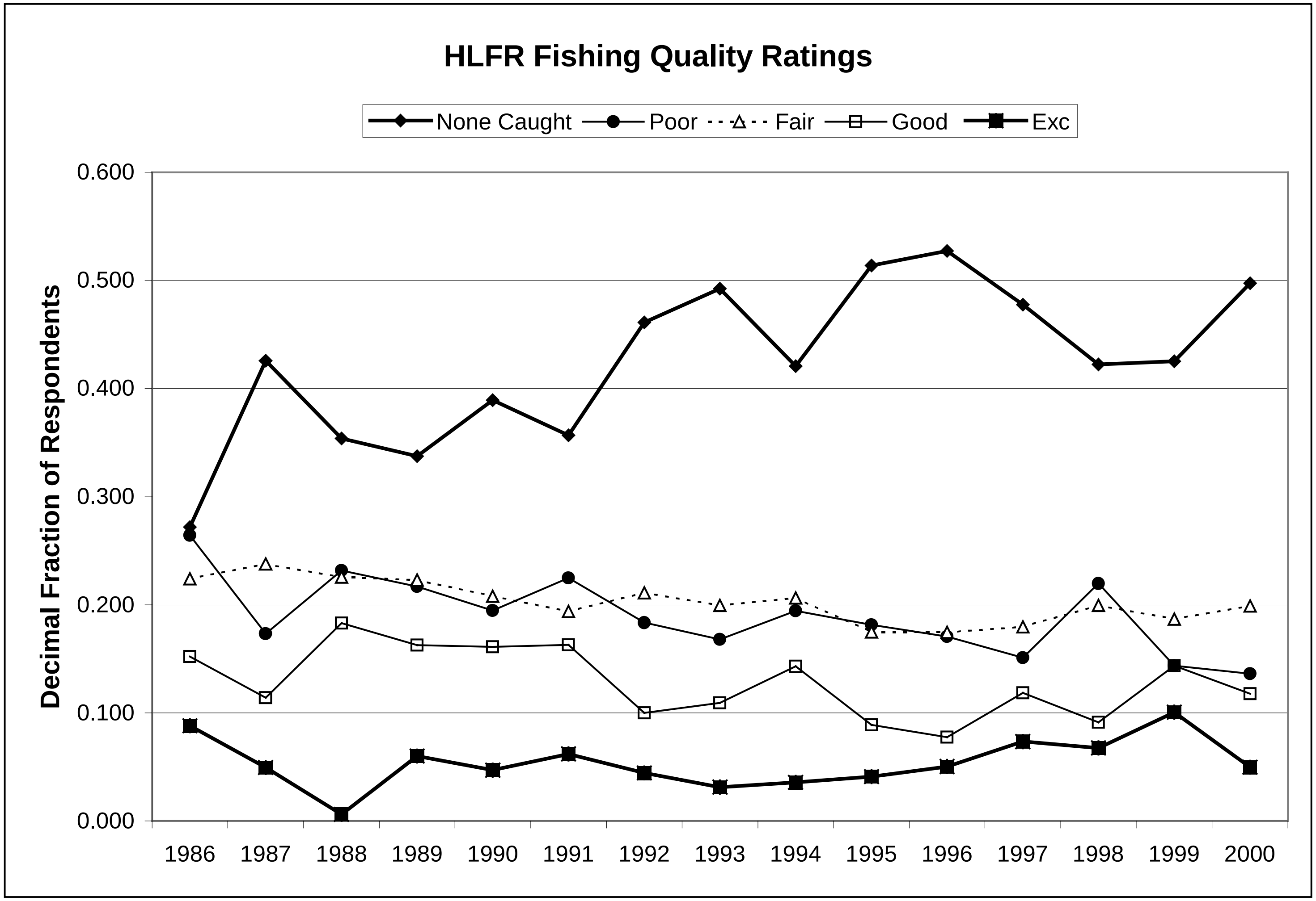
5.8.3 Measures of Satisfaction

Angler satisfaction with the high lake program was nearly identical in the 1986 and 1995 statewide angler surveys. About 44 percent of the survey respondents rated high lake angling "good to excellent" in Washington (WDFW 1996a; Plate 84). This survey result can be compared to the statistics gathered on angler satisfaction through the volunteer-based High Lake Fishing Report (see Section 5.2.1 and Appendix D). Statistics have been generated from this form since the summer of 1986, but from a far smaller user group than fishing license-buyers at large. Also, the volunteers filling this form out tend to be members of organized high lake fishing clubs, and probably have very different (e.g., more demanding) attitudes and expectations concerning a high lake fishing experience than the public at large.

There is no statewide, standardized approach to gauging angler satisfaction with the high lake fishery, with the exception of the 1995 angler survey (WDFW 1996a). However, the High Lake Fishing Report form (Appendix D) could serve this purpose as is, or with slight modification. It currently asks anglers to rate the "Quality of Fishing" they experienced on an individual outing. Admittedly, this is not exactly the same as asking an angler if he/she had a satisfactory outing (Moeller and Engelken 1972), but is probably close enough for fishery management purposes. The High Lake Fishing Report form gives ratings feedback to the manager on an individual lake basis, which is critical. By contrast, statewide assessments of license buyer satisfaction with the overall high lake program have only occurred every 9 to 10 years, or more.

Figure 21 plots the percent (decimal fraction) of each year's High Lake Fishing Reports (HLFR), by rating, from the HLFR database for each year since 1986. The number of reports per year ranged from 125 in 1986 to 382 in 2000, and averaged 230. These results are quite different from what was reported in the 1995 statewide angler survey (WDFW 1996a), probably because the data in Figure 21 were from more sophisticated high lake anglers. On average since 1986, 18 percent of anglers submitting HLFRs rated the quality of their fishing either good or excellent. An average of nearly 43 percent caught no fish (50 percent in 2000). It is clear that current fishing quality is not meeting at least one manager's objective of "most trip reports from a lake (giving) 'good' to 'excellent' ratings on trip and fish quality". The results plotted in Figure 21 are so far from that standard it may be asked whether it is a realistic objective. If the standard is realistic, Figure 21 indicates WDFW needs to apply more work to the high lake fishery product it is providing. Systematic elimination of stunted, low-quality fish populations would be an excellent next step.

Figure 21. Ratings of Washington High Lake Fishing Quality by Anglers Who Submitted High Lake Fishing Reports, 1986 to 2000.



The results from the HLFR database may be biased downward by virtue of the fact that many of the surveys being reported on are surveys requested by WDFW biologists. These are often requests to obtain information on a lake that has received little attention, has not been stocked in many years, needs a baseline survey, etc. At a minimum the HLFR database should not be considered an unbiased measure of the satisfaction of the high lake angling public at large. A better sample may be to query the database for the most recent 8 to 10 reports from each lake, rather than all reports for each year.

5.8.4 Appreciative Viewing / Non-Consumptive Uses

Since fish are not native to most high lakes in Washington, they are expressly stocked to provide a consumptive recreational fishery. However, there are many lakes with reproducing trout, char, or grayling that provide unusually good opportunities for viewing salmonids in their natural environment. Many high lakes have exceptional water quality and transparency, enhancing the ability to view fish. This unquestionably adds to the enjoyment, wilderness experience, and wildlife appreciation of many users, particularly children. Stocks used in the Washington high lake fishery program often attain their most dramatic coloration or condition in well-managed high lakes (Plates 44, 45, 58, 84, 85, 86).

5.8.5 Assessment and Recommendations

There is no evidence or expectation that the number of users of Washington's high lake fishery is going anywhere but up. "People management" is in many ways a larger issue than fish or fishery management, particularly with respect to meeting the terms and intent of the Wilderness Act of 1964 (Public Law 88-577). Many lakes, particularly those that are off-trail destinations, are largely self-limiting on use, depending on access difficulty. WDFW local managers face the dual challenge of balancing angler effort with trout abundance, growth rates, and ecological impact, while at the same time considering the effect of the fishery on the land and wilderness values (see Section 5.9).

Better measures of angler use on a lake by lake basis would help managers refine their decisions on stocking density and frequency. Expansion of the use of the High Lake Fishing Report form, and analysis of the existing HLFR database, may help further these local refinements. Closer coordination with, or cooperation from land managers such as the Forest Service or DNR could lead to acquisition of much valuable data on local angler use. Additional human resources are needed to accomplish either of these management objectives in a timely manner.

Managers have the ability, and typically try to manage for higher quality in lakes that do not have reproducing trout or char, especially in lakes that are off-trail, or that receive only moderate or lower use. Their ability to do this would be greatly extended if a program were initiated to annually rehabilitate several high lakes having excessive fish.

Relatively low angler satisfaction ("fishing quality") levels in the High Lake Fishing Report database suggest a review should be made of the sampled angler population to see if it is representative of the public at large. In any case the causes of the low quality ratings should be determined.

Plate 84. This angler appears to be satisfied with the Twin Lakes cutthroat he took from a lake that has been stocked at about 70 fish/ac every 6 or 7 years since 1953. The lake is in the Skykomish River drainage, and is unusual in that it supports good numbers of Gammarus. This macroinvertebrate has not suffered any obvious depletion despite many years of coexistence with trout.

Plate 85. WDFW Biologist Jim Cummins enjoys a 19.25 inch Twin Lakes cutthroat from a lake in the Henry M. Jackson Wilderness. (July 1977) Gerry Ring Erickson photo.

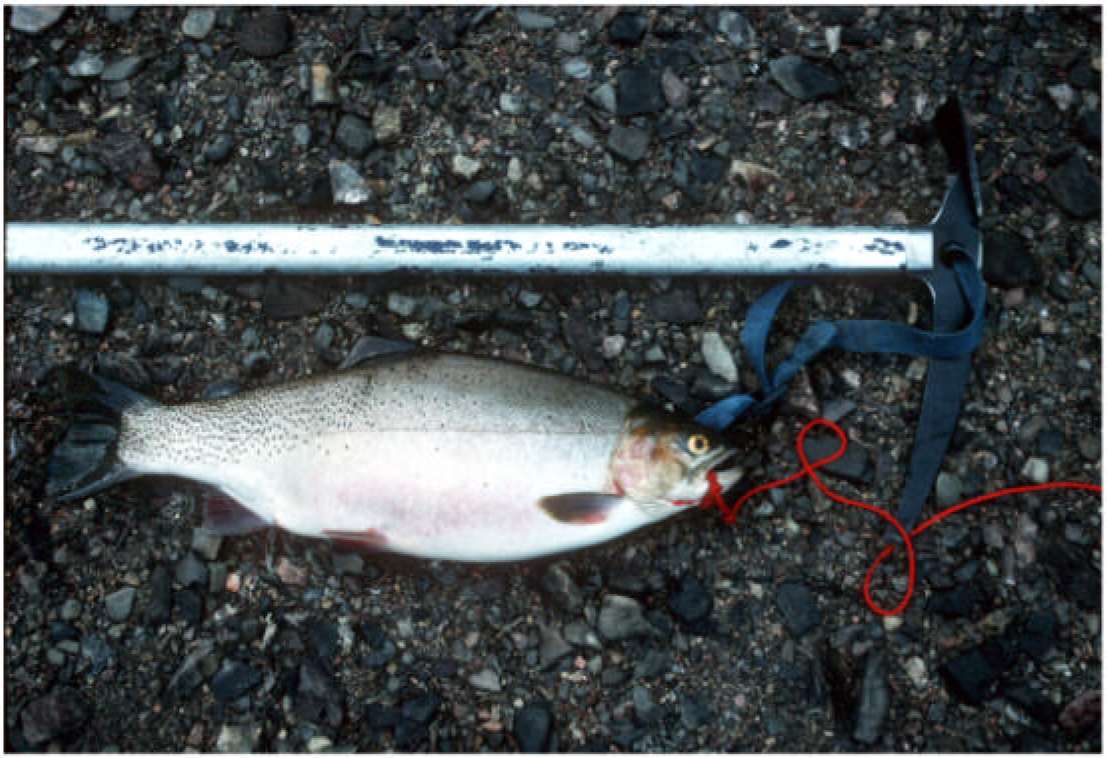


Plate 86. Twin Lake cutthroat can obtain exceptional condition when growing conditions are right. The high lake that produced this fish is stocked at low density on an annual basis. (October 1988)

Although the high lake fishery is primarily consumptive, managers need to be mindful of its non-consumptive benefits. These values should be quantified, if possible, so that all legitimate aspects of the fishery are considered in decisions that affect maintenance of individual lakes, or the collective fishery.

Recommendation #1: Local managers should be allocated the time to annually coordinate with volunteers to assure that the High Lake Fishing Report form and volunteer-based monitoring (Section 5.2.1) are utilized. This is a highly cost-effective way for WDFW to obtain needed information. Time or monies should be devoted to working with the Washington State Hi-Lakers or Trail Blazers, Inc. in preparing lake by lake catch, harvest, and effort statistics from the existing HLFR database for use by local managers.

Recommendation #2: WDFW should finalize earlier efforts to define statewide Goals and Objectives for the high lake fishery program. These should be general, allowing the essential flexibility needed to tailor objectives to individual lakes. Their principal purpose and value would be to publicize and memorialize the agency's overall direction for this fishery with more specificity than that published in 1981. Objectives should be quantifiable, to the degree possible, so that statewide or regional statistics can be used to measure overall program success.

Recommendation #3: Periodic surveys of angler preferences and use levels need to continue. Future surveys should pay special attention to the high lake fishery since it is one of the most cost-effective the agency manages.

5.9 INTERAGENCY AND LANDOWNER COORDINATION

The WDFW does not manage the high lake fishery in a vacuum. Coordination with major private timber owners, state agencies, and federal land managers has been an integral part of the program for decades. While WDFW retains the primary authority and responsibility for management of all fish and wildlife within the state (Title 77 Revised Code of Washington; RCW 77.04.012; RCW 77.04.020), other landowners and agencies control access and land management activities on the majority of lands that contain the high lakes. Coordination with these other owners and managers is essential, and on-going.

5.9.1 US Forest Service

U.S. Forest Service management of high lake fisheries in Washington pre-dates the creation of the Washington Department of Game by many years (see Section 2). Since the State assumed this responsibility in 1933, the respective roles have been primarily that of fishery managers (State), and land base, access, and human use managers (USFS). Designation of extensive areas as wilderness beginning in the 1960s has intensified the need for coordination of these management roles.

Most local WDFW fishery managers have worked with local Ranger Districts or regional national forest staff to develop individual lake surveys and management plans (Williams 1972; Cummins 1973; Johnston 1973; Pfeifer and Peacock 1987; Lucas 1989). Recent cooperative high lake surveys have been funded by the Forest Service (Deleray and Barbee 1992). A great deal of cooperative survey work has been coordinated with USFS districts that has not been reduced to published reports (WDFW 1994). Much of the high lake survey work conducted in King, Snohomish, Skagit, and Whatcom Counties, involving hundreds of lakes, has been closely coordinated with scientists and managers of the Mt. Baker-Snoqualmie National Forest. The same is true of most other areas that have not yet had summary technical reports prepared (e.g., Gifford Pinchot and Wenatchee National Forests).

The manner in which lakes that occur in wilderness areas may be stocked is dictated by USFS policy and rules developed after passage of the Wilderness Act (IAFWA 1986). In general, those methods that were in use at the time of wilderness designation may continue to be used. However, WDFW managers are well aware of the shattering effect helicopter stocking can have on an individual's wilderness experience. It is important to keep in mind that aircraft stocking only occurs on a very small percentage of lakes that lie within wilderness. A fixed-wing fly-over typically occurs on one day in a 3 to 6 year time interval, and lasts less than one minute. These events are scheduled for weekdays during seasons when the probability of disturbing users is minimized. Most stocking of lakes in wilderness is accomplished using backpack or aircraft methods (92%); 56 percent of all stocking is done by backpack (Table 26).

Table 26. Methods Used to Stock High Lakes in Designated Wilderness Areas in Washington.[1]

	Number of Introductions by Stocking Method (Percent)				
Wilderness	**Number of Stocking Trips**	**Truck**	**Aircraft**	**Backpack**	**Horse Pack**
Mt. Baker	174	66 (38)	43 (25)	38 (22)	27 (16)
Noisy-Diobsud	23	0 (0)	18 (78)	5 (22)	0 (0)
North Cascades NP	142	0 (0)	57 (40)	82 (58)	3 (2)
Glacier Peak	438	0 (0)	177 (40)	229 (52)	32 (7)
Lk. Chelan / Sawtooth	27	0 (0)	11 (41)	15 (56)	1 (4)
Henry M. Jackson	213	0 (0)	90 (42)	99 (46)	24 (11)
Alpine Lakes	2112	0 (0)	679 (32)	1321 (63)	112 (5)
Boulder River	23	0 (0)	15 (65)	8 (35)	0 (0)
Norse Peak	26	0 (0)	11 (42)	11 (42)	4 (15)
William O. Douglas	154	0 (0)	83 (54)	53 (34)	18 (12)
Clearwater	26	0 (0)	0 (0)	20 (77)	6 (23)
Goat Rocks	39	0 (0)	4 (10)	34 (87)	1 (3)
Pasayten	86	0 (0)	68 (79)	18 (21)	0 (0)
The Brothers	13	0 (0)	5 (38)	8 (62)	0 (0)
Indian Heaven	13	0 (0)	5 (38)	8 (62)	0 (0)
Totals:	**3509**	**66 (2%)**	**1266 (36%)**	**1949 (56%)**	**228 (6%)**

[1] Based on available information in the Trail Blazers database. Wildernesses only listed if 10 or more introductions were logged.

In keeping with the 1986 IAFWA Guidelines, and a Master Memorandum of Understanding between the State of Washington and the USFS signed in 1988 (Appendix M), periodic meetings are held between local USFS district staff and WDFW staff. Matters of mutual interest are discussed, and management problems resolved. The annual statewide alpine lake stocking program is coordinated with several forests through local meetings in a few key geographic locations.

Sharing of data and resources is a common occurrence at the local level. Technical documents that have been prepared almost universally acknowledge the contributions of counterpart agencies (e.g., Johnston 1973; Lucas 1989; USFS 1997). Previous planning efforts to initiate rehabilitation of lakes with stunted eastern brook have required close coordination between WDFW and the USFS (Weinheimer and Kearney 1983), as will future efforts along this line.

Overuse of wilderness areas is a matter of great mutual concern. Most high lake anglers consider crowding an impact on their wilderness fishing experience (Hendee et al. 1977). However, fishing alone is rarely the primary cause of overuse at specific lakes (Hendee et al. 1968). WDFW local fishery managers do, nevertheless, coordinate closely with USFS recreation staff to design fishery management plans that meet the needs of both agencies, to the greatest extent possible. A few lakes in areas where recreational use is grossly out of compliance with wilderness management standards (Wenatchee National Forest and Mt. Baker-Snoqualmie National Forest 1990) have been purposefully left barren to assist local USFS staff. Some of these lakes have a prior history of stocking. Concessions have been made in rare instances to reduce impacts on unusually fragile areas, even though it is recognized that users would flock to most of these lakes because of their extreme scenic beauty (Plate 87), whether or not they contained fish. WDFW considers these overuse problems people management challenges in the majority of cases, not fish stocking issues.

5.9.2 National Park Service

Active management of fisheries in high lakes that occur within a national park by the State of Washington only occurs in North Cascades National Park (NCNP). Maintenance of fisheries in this park is based on understandings that occurred at the time the park was founded. Current stocking and individual lake management is authorized and coordinated by the terms of a Supplemental Agreement to a Memorandum of Understanding between the National Park Service (NPS) and WDFW, signed in 1988. The 1988 Supplemental Agreement supplements the original Agreement, No. MU-9000-5-0004 dated August 15, 1985. The Supplemental Agreement establishes a mutually agreed to list of lakes in which continued stocking will be allowed.

WDFW has coordinated closely with NPS staff on the issues surrounding fish stocking in NCNP. WDFW scientists have served a peer review role on studies that have occurred (Liss et al. 1995), both on the early research designs, and on final report drafts. WDFW’s most experienced high lake biologists (Johnston, Pfeifer) have worked closely with NCNP staff over the past 15 years in conducting lake surveys, coordinating stocking with research activities, and working to resolve disagreement on matters of policy.

WDFW also coordinates with NPS staff on wildlife management issues. These occasionally overlap with high lake fisheries management. WDFW staff worked closely with NCNP staff in reducing fishery season length by adjusting published regulations in order to protect nesting loons and denning wolves in areas near the north end of Ross Lake (reservoir).

Plate 87. Aptly-named Gem Lake, in the Snoqualmie Pass group of peaks, actually drains to the Middle Fork Snoqualmie River. It receives heavy hiking and camping use, and has held fish in the past. It has not been stocked since 1963, although it is recognized that the presence of fish in the lake would probably not have much effect on nearshore use (see Plate 35). Background peaks are Chair Peak, Kaleetan Peak, and Mt. Roosevelt. (12 September 1991)

5.9.3 Washington Department of Natural Resources; Major Timberlands Managers

There is generally a clear separation of management authority between WDFW and the Washington Department of Natural Resources (DNR), particularly in areas supporting high lakes. Staff of the sister agencies meet periodically, particularly at the local level, to coordinate on matters of mutual interest. These commonly involve land management activities under the purview of DNR, such as road and trail access, development, or maintenance. WDFW Habitat Biologists work with DNR on the design and permitting of timber sales to minimize the impacts of cutting units on nearby lakes and ponds.

Region 3 biologists have been working with DNR to reduce domestic cattle and sheep grazing impacts on stream environments in the forested zones of the Ahtanum drainage (South Central Cascades). Also working with timberland managers/private landowners in the same drainage to continue to allow anglers access to Blue and Green Lakes.

Most local WDFW fishery managers state they have little control over management actions taken by large private timber owners. Several west side managers agreed that loss of road access in the past decade has had a significant impact on their high lake program (Parametrix 2001)

5.9.4 Interagency/Academic Cooperative Projects

Interagency or academic co-op projects are a relatively rare occurrence in the high lake program. Their infrequency is largely due to WDFW staff workloads and resources. Where cooperative projects have occurred, they have been highly beneficial.

Deleray and Barbee (1992) expanded the number of high lake surveys in Yakima County by 32 lakes in the summer of 1991. Their work provided useful, if not essential information for managers of both the USFS and WDFW.

Pfeifer and Peacock (1987) ascertained the cause of Williams Lake's inability to support trout. Williams Lake lies in a broad meadow area in the headwaters of the Middle Fork Snoqualmie River (Plates 88, 89). The lake basin collects drainage from a mineralized plateau sprinkled with tarns ("Chain Lakes") on the shoulder of 6585-ft La Bohn Peak (Plate 90). Exploratory mining dating to early in the 20th century exposed mineralized tailings in the area draining to Williams Lake (Plate 91). Water quality sampling (Plate 92) and a lake bioassay (Plate 93) determined that high copper levels were the cause of fish mortality, and not a lack of dissolved oxygen in late winter (Plate 94). They obtained information on heavy metals in the Chain Lakes mining district in the watershed above Williams Lake and in Williams Lake itself (Plate 92) which supported the North Bend Ranger District's negotiations over purchase of a controversial mine inholding.

One of the most beneficial academic projects supported by WDFW was the thorough study of the life history of arctic grayling in the single Washington high lake where they occur (Beauchamp 1982). Apart from being a superb piece of scientific work, this study was of great value to local managers in determining whether the grayling could co-exist with westslope cutthroat.

Plate 88. Tracks emanate from an old mine adit near Williams Lake in the headwaters of the Middle Fork Snoqualmie River. Several inlets enter on the north (right) shore, draining the rugged Chain Lakes mining area. An arrow shows the spot where a late winter water sample was collected to ascertain dissolved oxygen content. (18 August 1987)

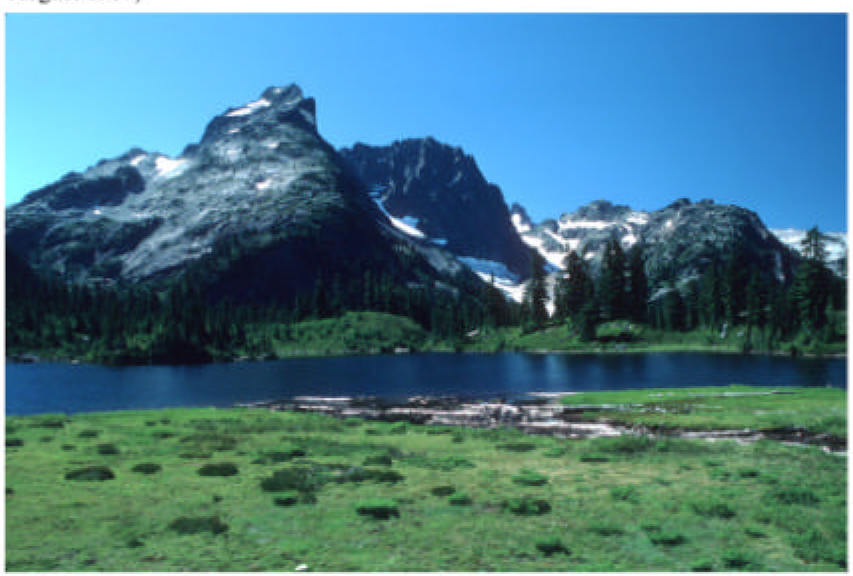


Plate 89. The principal inlet of Williams Lake faces Summit Chief Mountain. Although Williams Lake cannot support trout due to high copper content, cutthroat thrive in its outlet about one mile downstream, at Pedro Camp. Williams Lake receives moderately heavy recreational use despite its lack of a fishery. (18 August 1987)

Plate 90. A sharp, or trained eye can pick out most of the 10 Chain Lakes in the lower right quarter of this photo. The wing tip points northwest, and touches 6585-ft La Bohn Peak. Williams Lake is just out of the photo at lower left. The arrow shows mine tailings that are also plainly visible in Plate 91. (13 July 1987)

Plate 91. The largest of the Chain Lakes lies below two mine shafts, one of which contributes tailings and leachate to this, and lower lakes. The left arrow indicates the location of a vertical shaft; the right arrow shows tailings at same location as in Plate 90. (18 August 1987)

Plate 92. USFS hydrologist Kathi Peacock collects water samples and conductivity readings near the mouth of one of the small inlets at Williams Lake. (18 August 1987)

Plate 93. Trout survived less than 12 hours in this minnow trap that was positioned where there was adequate exchange of water. (24 September 1987)

Plate 94. An early May field trip found the lake still fully covered with snow at its inlets. Mid-lake and near-bottom water samples were saturated with oxygen, ruling out winterkill as a limiting factor for trout survival. The lake was sampled at its deepest point. (10 May 1988) Jim Jewell photo.

5.9.5 Assessment and Recommendations

WDFW has a long history of coordination and cooperation with other land managers. Cooperative projects have yielded many highly beneficial work products. Most of the problems in recent years stem from the burgeoning human population in Washington, and difficulty in meeting the terms of earlier legislation. Inconsiderate dumping and vandalism on state and private timberlands from a small minority has prompted DNR and private timber growers to erect gates on roads that lead to high lakes. USFS wilderness managers have greater and greater difficulty in meeting the standards set forth in the Wilderness Act due to ever-increasing levels of use. Special interest groups, ignorant of understandings and communications that occurred at the time the North Cascades National Park was created, exert pressure on NPS administrators to eliminate historic high lake fishing in NCNP.

> **Recommendation #1**: WDFW should continue to coordinate and cooperate with other land managers and agencies. The frequency of meetings with some agencies has slipped in recent years; this should be rectified, if possible. Annual or biannual workshops with federal land managers have historically been the most productive, and significantly increased communication and understanding.

> **Recommendation #2:** The 1988 Supplemental Agreement to the Memorandum of Understanding between the National Park Service and WDFW should be renegotiated. The negotiation should take advantage of the most current science available, this report, Divens et al. (2001), the extensive experience and library of the Trail Blazers, Inc., as well as relevant information that may be held by other parties or groups.

5.10 OUTREACH

Because of the misunderstanding of biological and ecological issues surrounding the high lake fishery in Washington**,** it is essential that the public be better informed and educated about the benefits and impacts of the program. That is one of the primary purposes of this report.

Numerous articles have appeared in newspaper, magazine, and special interest group newsletters in recent years that suggest that trout stocking in high lakes leads, *ipso facto*, to amphibian declines (Wilderness Watch 1992a; Forstenzer 1998, 2000). Differing points of view or hypotheses (Recer 1997; Cone 2000; Schoch 2001) are rarely, if ever mentioned by those who would ban trout stocking. The most recent research has, in fact, revealed that the situation is far from simple, and that amphibian declines may be the result of complex environmental interactions (Kiesecker et al. 2001). Only rarely is a differing point of view published (Johnston 1998).

Some groups believe trout should be banned from wilderness areas in which they are not native (Wilderness Watch 1992b). How many people know that the Alpine Lakes Wilderness Area was only created after President Ford was taken there on a <u>fishing</u> <u>trip</u> so he could view its near-pristine lakes, rivers, and mountains (Wright 1993)? Fishing is a permitted activity in wilderness areas, as is fish stocking (IAFWA 1986).

Apart from these policy issues, there is always a need for basic education of the public about how the agency manages its high lake fishery resource. The fishery has unique safety issues associated with backcountry and off-trail hiking. And, since trout are put into high lakes primarily to be harvested, many users benefit from a guide on where to go to enjoy this resource.

5.10.1 High Lake Fishing Guide

Local WDFW managers routinely get seasonal calls from the public asking where they can go to fish a high lake; often a majority of these are asking about specific species, such as golden trout. In part to meet this information need, a "Primer" on the high lake fishery was written by Washington State Hi-Lakers member Gerry Ring Erickson, and WDFW Fish Biologist Bob Pfeifer in the mid-1980s.

The "Primer" had a modest beginning, being no more than a stapled series of pages. It included sections on the fish found in the fishery, fishing gear and techniques successful in high lakes, back country safety, a list of suggested lakes to visit to begin to learn about the fishery, and perhaps most important, a section on the Leave No Trace wilderness ethic.

The authors of the "Primer" recognized the sensitive nature of the high country, and the potential conflict with wilderness management by USFS staff. Therefore, a carefully selected list of lakes was chosen for the "Suggested Lakes" section. The list was drafted with the help of the two major high lake fishing clubs in the Seattle area (Washington State Hi-Lakers, and Trail Blazers, Inc.). The lake list was also edited by all affected local WDFW fishery managers. An agreed-to list of lakes was then mailed to each of the affected Forest Service district offices to obtain their feedback. A few lakes were removed from the list, and a few were added. In general, the lakes are ones which have had high numbers of users for many years, have well-maintained trails and camping areas, and are large lakes, with fish populations that can withstand fairly heavy fishing pressure.

The Primer was initially published in 1986 in *Signpost For Outdoor Trails* magazine. For years the stapled sheets version of the Primer was copied by WDFW regional office staffs for distribution. In the mid-1990s it was given a more professional appearance by the agency's publications department. It has been distributed to WDFW regional offices where demand typically quickly outruns annual supply. It was revised slightly in the late 1990s, and now appears renamed on the agency website as a Fishing Guide entitled "Trout Fishing in Washington's High Lakes" (below).

5.10.2 Agency Website

WDFW, like all modern agencies, has an Internet website for broad dissemination of information. The former High Lake Fishing Primer can now be found at the following website address: http://www.wa.gov/wdfw/outreach/fishing/highlake.htm. It is one of 11 features in the "Fishing Guides and Tips" section accessed by the "Fishing & Shellfishing" tab on the home page.

5.10.3 Sport Club Coordination

Coordination with hunting and fishing clubs is, of course, standard procedure with WDFW, like all fish and wildlife agencies. Local fishery management biologists regularly meet with constituent groups to present programs, discuss issues, or simply attend to maintain communication. Many clubs receive regular mailings of information from the agency. Close agency coordination with the Trail Blazers is a long tradition (Yadon et al. 1993) – longer than with the Washington State Hi-Lakers only because the Trail Blazers' founding in 1933 preceded the Hi-Lakers by 25 years. Regular contact is maintained with the Back Country Horsemen as well, although generally through one or two contact individuals, rather than by attendance at club meetings.

The special coordination that occurs with the Washington State Hi-Lakers was discussed in Section 5.2.1 because of this club's focus on high lake surveys. Aspects of Trail Blazer coordination were covered in Sections 5.4.5 because of this club's major role in assisting WDFW with stocking the many small, remote wilderness waters, and their exceptionally valuable historical databases.

5.10.4 Assessment and Recommendations

The agency's outreach effectiveness has probably been greatly extended in recent years with the development of its website. However, while the "runs" on the High Lakes Fishing Primer were tangible evidence of public contact, the number of times the website's *Trout Fishing in Washington High Lakes* page is accessed is less apparent to WDFW fishery managers. In the last year or two there has been a significant drop in WDFW local biologist contact with the two key high lake fishing clubs in the Seattle area. This is particularly troubling as it may result in diminished monitoring, or reduced quality or usefulness of the data collected.

Recommendation #1: The agency webmaster should perform an annual "page analysis" on the *Trout Fishing in Washington High Lakes* feature to monitor the approximate number of new individuals who obtain this information. The annual summary statistics of this analysis should be circulated within WDFW. The guide also needs to be updated to reflect changes in access, and better local understanding of individual fisheries since the original publication.

Recommendation #2: This report should be made available to the public at large on the agency website.

Recommendation #3: The benefits and values generated by the high lake fishery needs to be widely distributed to the public and internal and external policy makers.

Recommendation #4: Because of the key role the two Seattle high lake fishing clubs and the Back Country Horsemen play in WDFW's high lake stocking and monitoring programs, time should be made available to local fishery management biologists to maintain an adequate amount of coordination communication.